ADOPTION OF IMPROVED CHICKPEA TECHNOLOGIES IN NORTH GONDAR ZONE OF ETHIOPIA: THE CASE OF GONDAR ZURIA DISTRICT

M.Sc. Research Thesis

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November, 2017

University of Gondar

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Adoption of Improved Chickpea Technologies in North Gondar Zone of Ethiopia: The Case of Gondar Zuria District.

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UNIVERSITY OF GONDAR

COLLEGE OF AGRICULTURE AND RURAL TRANSFORMATION

DEPARTMENT OF AGRICULTURAL ECONOMICS

ADOPTION OF IMPROVED CHICKPEA TECHNOLOGIES IN NORTH GONDAR ZONE OF ETHIOPIA: THE CASE OF GONDAR ZURIA DISTRICT

A Thesis Submitted to the Department of Agricultural Economics

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Agricultural Economics

By

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November, 2017

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A thesis research advisor, I hereby certify that I have read and evaluated this thesis prepared under my guidance by Mesfin Fenta entitled ‘‘Adoption of Improved Chickpea Technologies in North Gondar Zone of Ethiopia: The Case of Gondar Zuria District’’. I recommend that it be submitted as fulfilling the thesis requirement.

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As mentioned of the Board of Examiners of the M.Sc. thesis open defense examined. We certified that we have read and evaluated the thesis prepared by Mesfin Fenta and examined the candidate. We recommend that the thesis be accepted as fulfilling the thesis requirements for the degree of Master of Science in Agricultural Economics.

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DEDICATION

This manuscript is dedicated to my family for their unreserved eager to see my dream be true.

STATEMENT OF AUTHOR

By my signature below, I declare and affirm that this is my own work. I have followed all ethical principle of scholarship in the preparation, data collection, data analysis and completion of this thesis. All scholarly matter that is included in the thesis has been given recognition through citation. I affirm that I have cited and referenced all sources used in this document. Every serious effort has been made to avoid any plagiarism in the preparation of this thesis.

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BIBLIOGRAPHIC SKETCH

The author was born at kolladiba town, Dembia district, North Gondar Administrative Zone, Amhara National Regional State in March 1982. He attended and completed his junior and senior secondary school at kolladiba town. He joined the former Ambo College Agriculture, now Ambo University and earned diploma in general agriculture in 2003. After graduation, he worked crop production expert in Tegede District until he joined Gondar Agricultural Research Center as technical assistant in 2005. Later, he joined University of Gondar to advance to the degree of Bachelor of Art (BA) in economics and received in 2010. After graduation, he continued serving Gondar Agricultural Research Center as socio-economics research assistant position in Socio-economics and Agricultural Extension Research Directorate. He then joined University of Gondar in September 2015 to pursue a study leading to the degree of Masters of Science (MSc) in Agricultural Economics.

ACKNOWLEDGMENT

I would like thanks many people and organizations who have supported me in accomplishing thesis work. My greatest and special gratitude go to my major advisor, Dr. Akalu Teshome for his professional guidance, encouragement, valuable comments and suggestions throughout the whole research process. My deepest thanks also to my co-advisor Dr. Wondimhunegn Ezezew, Dr. Workeneh Kassa and Mr. Tamiru Amanu for their technical and professional support and comments in this thesis work.

I gratefully acknowledge Amhara Regional Agricultural Research Institute for providing the chance to do my second degree and University of Gondar for providing me educational opportunity. I would like thanks to N2-Africa ILRI Ethiopia project for generous research financial grant to this research study.

I would like thanks to Mr. Tsedalu Jemberu, Director of Gondar Agricultural Research Center for his moral support, facilitating and organizing logistics during research time. Many thanks go to my friends Mr. Asmamaw Bidiru, Mr. Andualem Tadesse, Mr. Solomon Gizachew and Mr. Yonas Worku and their encouragement and moral support during my thesis research study.

My beloved, Mother and Father deserve special thanks for their raised me up in love and affection, support and encouragement. I would like also tremendous thanks to Mrs. Zinash Milakew for your love, patience, unlimited support, providing your precious time during my research time.

The efforts of people who devoted their time and resources to assist me in the process of this study are greatly acknowledged. This study would have been, beyond doubt, impossible had it been for the kind help of a number of good people, colleagues and friends.

I am also thankful to all enumerators who assisted me in data collection with commitment and dedication. I am grateful to all respondent farmers and agricultural experts for providing valuable time and necessary information for this research work.

ABBREVIATIONS AND ACRONYMS

ANRS	Amhara National Regional State
ARARI	Amhara Regional Agricultural Research Institue
BoA	Bureau of Agriculture
CSA	Central Statistical Agency
DAP	Di-Ammonium Phosphate
DoA	District of Agriculture
EARO	Ethiopian Agricultural Research Organization
EDHS	Ethiopian Demographic and Health Survey
EIAR	Ethiopian Institute of Agricultural Research
ETB	Ethiopian Birr
EUT	Expected Utility Theory
FGD	Focus Group Discussion
FTC	Farmers' Training Center
GDP	Gross Domestic Product
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IJAIR	International Journal of Agriculture Innovations and Research
ILRI	International Livestock Research Institute
NGO	Non-Governmental Organization
OLS	Ordinary Least Square
TL	Tropical Legumes
TLU	Tropical Livestock Unit
TPB	Theory of Planned Behavior
TRA	Theory of Reasoned Action
UNDP	United Nations Development Program
USD	United State Dollar

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ABSTRACT

Adoption of improved technologies is seen as a key driver to increase agricultural production and productivity in Ethiopia. Considerable efforts have been made by government and NGOs to disseminate improved technologies in order to boost production and productivity chickpea though the outcome is not impressive. The purpose of this study was to analyze drivers of chickpea technologies adoption and farmers' preference to adopt chickpea in Gondar Zuria district. This study used cross-sectional data in 2015/16 production season from the sample of 224 household heads selected through multi-stage sampling technique. Descriptive and econometrics models were employed to analyze the data. Tobit model was used to identify factors affecting adoption decision. FTC distance, farm income, livestock owned, agricultural training and credit access have significantly affected the adoption of improved chickpea varieties. Age, experience, livestock holding, number of people rely on, field days, trainings, market and road distances have significantly influenced the adoption of bio-inoculant fertilizer. Age, family size, asset holding, land size, number of people rely on, sex, education status, radio ownership, agricultural training and perception have significantly influenced the adoption of chemical fertilizer. An Ordered Probit model was also used to identify levels of adoption of improved chickpea technologies. These are non-adopters (36.6%), low adopters (31.3%), medium adopters (24.1%) and high adopters (8.0%) of improved chickpea technologies. The result indicate that farm income, livestock size, agricultural training, credit access and FTC distance have significantly influenced levels of adoption of improved chickpea technologies. Conjoint analysis was used to know farmers' preference on the improved chickpea technologies. The result indicate that variety, payment option, chemical fertilizer and bio-inoculant have 45%, 28%, 14% and 13% share of relative importance, respectively. Shasho variety, DAP fertilizer, bio-inoculant and 50% pre-payment as a package has the highest preference value and ranked the first from different packages. Based on the findings, government and NGOs should give emphasis on strengthen field days and trainings, the provision education, encouraging livestock rearing, strengthening credit access, encouraging farmers' cooperative, strengthening rural infrastructure, promoting resource endowment, and arranging experience sharing. Lastly, Shasho, DAP fertilizer and bio-inoculant with credit access are preferred and should be promoted more in the study area.

Key words: *Chickpea technologies, Adoption, Preference, Tobit, Ordered Probit, Conjoint.*

1: INTRODUCTION

1.1. Background of the study

Ethiopian economy and employment are largely depending on agriculture sector. Its GDP reached 55 billion USD and per capita was 631 USD by the end of 2013/14. Agriculture, industry and services sectors contributed 40%, 14% and 46%, respectively to the GDP. In the total employment opportunities, 72.7% was generated from agriculture sector and the other 19.8% and 7.4% generated from service and industry sectors, respectively, (UNDP, 2015). However, the agriculture, services and industry sectors accounted for 38.8%, 46.6% and 15.2% of real GDP, respectively. Despite its declining contribution to GDP over the years, agriculture leading sector in the contribution to the country's overall economy. It is a major source of food, raw material for the domestic industries and commodities export (UNDP *et al*., 2016).

Most of Ethiopian population, residing in the rural area, is engaged in agricultural as a major means of livelihood. However, the agricultural productivity is low due to use of low level of improved agricultural technologies, risks associated with weather conditions, diseases and pests, etc. Moreover, due to the ever increasing population pressure, the landholding per household is declining leading to low level of production to meet the consumption requirement of the households (Bezabih and Hadera, 2007).

There are different pathways that help out of poverty i.e intensification of smallholder agriculture, commercialization, diversification, migration and urbanization. The pathway out of poverty trap in Ethiopia depends on the growth of the agricultural sector since agriculture is the mainstay of the country's economy and drive the livelihood of the majority of the poor. Yield enhancing technical options should be there to achieve agricultural growth and development because without improved agricultural technologies it is no longer possible to meet the needs of increasing numbers of people by expanding areas under cultivation (Menale *et al.*, 2010).

Chickpea is one of pulse crops, which is cultivated in above 40 countries of the globe around 11 million ha of land from which over 8 million tons of seed is yearly harvested. The major producers are India, Pakistan, Turkey, Australia, Iran, Myanmar, Canada, Ethiopia, Mexico and Iraq with over 93% of the global production. In Africa, chickpea is widely grown in Ethiopia, Sudan, Eritrea, Kenya, Tanzania and Malawi. It contributes around 46% of the total production in Africa (Menale *et al*., 2009). In Ethiopia, chickpea ranks third in area coverage from among the pulses grown areas and proceeded by Faba bean and Field pea and second in volume of production only next to Faba bean. In the country, with a total area of 229,720.74 ha land and its productivity was 1.85 ton hectare (CSA, 2014).

In our country, chickpea is widely grown across the country and serves as a multi-purpose crop. Chickpea provides the small farm households alternative sources of protein, energy, minerals and cash income. In addition, its residue is used as animal feed and it enhances fertility of the soil (Bekele *et al*., 2007). It is produced for different purposes including food and feed, cash and foreign currency earnings. In addition, it replenishes soil fertility as it fixes a substantial amount of atmospheric nitrogen in symbiotic association with different species of root nodule bacteria. However, the national average yield of chickpea in Ethiopia under farmers' production condition was around 0.8 tons per hectare. On the other hand, if improved technology packages used, the potential of the crop was more than 3 tons per hectare (Legesse *et al.,* 2005).

In view of this, the government of Ethiopia in an attempt to increase agricultural productivity and improved food security at both national and household level, efforts have been underway to generate and disseminate improved agricultural technologies among smallholder farmers. Over the past two decades, on-farm trials, demonstration and popularization of improved chickpea production technologies (improved varieties, fertilizers and management practices) have been undertaken in several potential chickpea producing areas to promote improved technologies and enhance their adoption (Legesse *et al.,* 2005; Million and Asnake, 2011).

So far many improved chickpea technologies have been released to increase chickpea production and productivity. However, due to various reasons the adoption of improved technologies is low. In the previous studies indicated that demographic, socioeconomic, institutional and infrastructure access factors, attitude towards the technology and communication condition of the household were significantly related to adoption and intensity of adoption of improved agricultural technologies (Almaz Giziew, 2008; Hassen Beshir, 2013; Akinbode and Bamire, 2015).

Even though many efforts have been conducted to popularize and disseminate improved chickpea technologies among farmers of *Gondar Zuria* District, the adoption of improved technologies are not impressive. Why farmers are resisting or adopting and levels of adopting about improved chickpea technologies is a big question so far not answered with substantial evidence for the study area. Thus, this study is proposed with the objective of analyzing adoption of improved chickpea technologies and farmers' preference to the technologies in *Gondar Zuria* district, North Gondar Zone.

1.2. Statement of the problem

Pulse crops function as a natural fertilizer through nitrogen-fixing, which improves yields of other crops through crop rotation, and can also reduce smallholder farmers' expense for commercial fertilizer purchase. They also contribute significantly to Ethiopia's foreign currency and the third-largest export crop after coffee and sesame, contributing 90 million USD to export earnings (Shahidur *et al.,* 2010). Chickpea is one of very important pulse crops in Ethiopia contributing to about 17% of the countries' total pulse production. Ethiopia is the first chickpea growing country in Africa, with a share of about 37% in area and 63% in production and the seventh chickpea producer in the world. Amhara National Regional State (ANRS) has 61.5% in chickpea cultivated area and 60% in production share from the country. North Gondar Administrative Zone also contributes more than 25% of chickpea cultivated area share in the region (Menale *et al.,* 2009). However, the area share of chickpea cultivated land was increased to 31.10% and 35% production share in 2013/14 production season (CSA, 2014; TL-III, 2016).

In order to increase production and productivity, using technologies are very determinant factor for economic growth and development. Agricultural technologies, improved crop varieties are helping to improve income and livelihoods for subsistence farmers. Agricultural research institute and international projects introduced a number of technology package, each consisting of an improved crop varieties and improved management methods (tillage, seed rate, planting date, fertilizer application rate, weed and pest control, and irrigation schedule) to maximize the benefits from the variety. Packages were developed for different crops, and different varieties of each crop. Studies indicated that, farmers who adopted technology packages (or components) obtained crop yields 8% to 70% higher than non-adopters. In Ethiopia, chickpea crop production technology adopters earned a significant higher net return which was USD 551 per hectare than non-adopters (ICARDA, 2008).

In the previous years, to get higher benefit from chickpea crop, international crops research institute for the semi-arid tropics (ICRISAT) collaboration with the Ethiopian Institute of Agriculture Research (EIAR) has developed several high yielding, stress tolerant and marketable varieties of chickpea with desirable agronomic management (Solomon *et al.*, 2011). Agricultural research institutes, Bureau of Agricultural (BoA), technology producer organizations, different NGOs and institutions had been undertaking on farm technology demonstration, popularization and multiplication activities in order to facilitate the transfer of technologies to farmers in the country. Improved chickpea varieties (*Arerti*, *Shasho* and *Natoli*) with recommended bio-inoculant, chemical (DAP) fertilizers and management practices were promoted intensively in *Gondar Zuria* and *Dembia* Districts to boost chickpea production and productivity.

Although these efforts and potentials, different studies indicated that, the adoption of improved technologies was very low. Among the total chickpea cultivated area (194,981 ha) only 0.69% was covered by improved chickpea varieties (Solomon *et al.,* 2010). It has been recognized that the continuous use of local low yielding crop varieties is a major cause of low productivity. The main reasons indicated for low adoption rates are insufficient seed and marketing systems that limit the availability of quality improved seeds, lack of credit, and late delivery of inputs (Menale *et al*., 2009). Other studies also pointed out that the total quantity of improved seed supplied nationally has been increasing, however, the adoption of improved varieties was around 3% to 5% of cropped area was under improved varieties (Spielman *et al.*, 2012). The productivity of chickpea was low according to its potential i.e 1.85 ton per hectare (CSA, 2014). In addition, the market share of the country from the world was low i.e about 4% by volume (TL-III, 2016). There is a need to identify the reason for low productivity of chickpea.

Gondar Zuria District has potential farm land, favorable environmental condition, availability of improved technologies and good national and international market opportunities for chickpea production. To make use of the potential of the crop over the past, on-farm trials, demonstration and scale up/out of these improved chickpea production technologies (improved varieties, bio-inoculant, DAP fertilizer and management practices) have been undertaken by government and NGOs in several chickpea producing areas of the region to promote improved technologies and enhance their adoption by farmers. In this District, improved chickpea technologies were popularized to improve the food security status of farmers and increase their income.

In spite of such intervention, information with regard to level of adoption of pulse crops in general and chickpea production in particular, on locally specific factors that hinder or promote adoption and variation among farmers in their intensity of adoption of improved chickpea production package practices are scanty in the study areas. Studies by Solomon *et al.* (2010), Simtowe *et al*. (2011), Tesfaye *et al.* (2014), Akalu *et al.*(2016) and Sisay Debebe (2016) reported that location specific socio-cultural, institutional, infrastructure, demographic and communication variables significantly affect technology adoption behavior of farmers. Since farmers of *Gondar Zuria* District have different geographic location and culture practices their problems related to technology adoption might be different and level of adoption of technologies on chickpea production was not known, this study intended to find out those problems. On the study area, many farmers are using local varieties and traditional agronomic practices for the production of chickpea crop.

To promote higher levels of adoption, understanding conditions of adoption of recommended technologies and current improved chickpea technologies preference are important concerns for the people dealing with agricultural development. This study is focused on factors determining adoption of chickpea technologies particularly in the study area.

1.3. Research Questions

This study has attempted to answer the following important research questions:

1. What are factors important in influencing adoption of improved chickpea technologies in the study area?

2. What are the levels of adoption of improved chickpea technologies?
3. What are the improved chickpea technologies preferred to adopt by farmers?

1.4. Objective of the study

General objective

The overall objective of this study is to analyze adoption of improved chickpea technologies by smallholder farmers in their farming system in *Gondar Zuria* District.

Specific objectives

1. To identify drivers of adoption of improved chickpea technologies (improved varieties, bio-inoculants and chemical fertilizer).
2. To determine levels of adoption of chickpea technologies in the study area.
3. To assess farmers' preference to adopt improved chickpea technologies in the study area.

1.5. Significance of the study

The remarkable productivity growth in the agricultural sector of the world mainly comes from the technological improvement. It is proved from the Asian and some Latin countries that the green revolution is able to increase the productivity of the farmers very significant. Adoption agricultural technologies can boost production and productivity of crops. Similarly, chickpea crop production and productivity is enhanced by different improved technologies. Improved technologies were developed by researchers in different time. *Gondar Zuria* district has one of the best suitable lands for chickpea production both in rainfall and irrigation condition.

However, the adoption of technologies in the farmers seems very sluggish. Farmers' are not always adopting the newly introduced technologies that came to them from any extension organization as it is immediately. They try to evaluate according to its match with their social, environment and economic importance (Bezabih and Hadera, 2007).

So, knowing derivers and levels of improved chickpea technologies adoption by farmers have a paramount importance for the researchers to develop agricultural technologies and for the agricultural extensions to make scale out and promote more which suits to the current setting conditions of farmers. Decision makers too will benefit from the research output since they require micro level information to formulate and revise strategies concerning agricultural research and extension.

Thus, the study assumed to produce very important information on locally specific factors related to economic, social, cultural, institutional factors and farmers' preference and perception on improved chickpea technologies. Finally, the information produced from this study will contribute for technology generators, extension agents, input suppliers and other organization working in agricultural sector to improve their service for the production chickpea.

The findings of this study will enable agricultural researchers, higher education institutions and peoples working on agricultural development to redirect their research focus based on the real situation and demand of farmers. An understanding of the processes leading to the adoption of new technologies by farmers will be important to the planning and implementation of successful research and extension programs.

1.6. Scope and limitations of the study

The study was conducted in *Gondar Zuria* district of North Gondar administrative zone, Amhara National and Regional State (ANRS) and focus on understanding the determinants of adoption of improved chick pea technologies. Hence, the study was restricted to the assessment of factors affecting adoption, level of adoption on improved chickpea technologies and farmers' preference to adopt among different improved chickpea technologies package. Chickpea crop is selected for this study due to its importance for food consumption, high market demand, agronomic purpose and agro-ecological suitability to grow this crop in the study area. It is examined local specific factors such as demographic, social capital, institutional, infrastructure and access to agricultural extension service. The study was mainly based on the information generated from the sample household survey during a single cropping season using a cross-sectional data due to the limitation of time and logistics. Dynamic agricultural farming system and households behavior are determinant factors and vary from place to place. Hence, the generalizations might not be possible for the whole region of the country.

1.7. Organization of the Thesis

The first chapter has presented the introduction of the study. Chapter two presents literature review. The reviewed studies are in the area of basic concepts of technology adoption, technology adoption decision theories, technology adoption in the world, chickpea research and production in Ethiopia and analytical framework. Chapter three presents research methodology; includes study area description, sampling procedure, methods of data collection and data analysis. Results and discussions are presented in chapter four. Finally, chapter five concludes the study and presents policy recommendations.

2: LITERATURE REVIEW

2.1. The concept of adoption and perception

2.1.1. Basic concepts of adoption of innovation

Innovation is new ideas, methods, practices or object, which perceived as a new and provides the means of achieving, sustained increases in farm productivity and income. The innovation may not be new to people in general but, if an individual has not yet accepted it. Diffusion is a process by which new ideas or practice communicated to the members of social system over certain period of time (Rogers and Shoemaker, 1971).

According to Rogers (1962) adoption is process as the mental process through which an individual passes from the first hearing of about an innovation or technology to a final adoption. It is the integration of an innovation into farmers' normal farming activities over an extended period of time. The author also noted that, adoption is not a permanent behavior. This implies that an individual may decide to discontinue the use of an innovation for a variety of personal, institutional and social reasons one of which might be the availability of another practice that is better in farmers' fields. However, largely because of the complexity of adoption and diffusion behavior, as well as the impermeable boundaries and perspectives of the traditions and disciplines involve in this research, there is as yet no generally accepted theory available to guide the professionals in research of the factors affecting the adoption behavior.

2.1.2. Basic concepts of technology adoption

According to Loevinsohn *et al*. (2013), technology is the means and methods of producing goods and services. It is new to a particular place or group of farmers, but the technology may in use within a particular place or farmers. Technology adoption is important because it is the vehicle that allows most people to participate in a rapidly changing world where technology has become central to our lives. Individuals who can't adopt will increasingly limit their ability to participate fully in the financial and convenience benefits associated with technology. Understanding the factors influencing technology adoption helps us predict and manage who adopt, when and at what conditions. Unfortunately there is no clear definition of technology adoption, in large part due to the tremendous variability in types of technology and circumstances under which people adopt them.

Technology adoption and diffusion are highly interrelated but distinct concepts. Technology adoption is measured at one point in time while technology diffusion is the spread of a new technology across population over time (Thirtle and Ruttan, 1987). While explaining the distinction between these concepts, Rogers (1962) argued that, technology (synonymously used with the term innovation) is often accompanied by two processes, namely the processes of adoption and diffusion. Technology is described as an idea, practice, or object that is perceived as new by an individual or groups of a society. Technology adoption is the use or non-use of a new or improved technology by an individual or farmer at a given period of time. On the other hand, technology diffusion is defined as "the process by which a technology is communicated through certain channels over time among the members of social systems". It signifies a group of phenomena, which suggests how technology spreads among users. It takes place at the individual level and is the mental process that starts when an individual first hears about the technology and ends to its final adoption or rejection.

Rogers (1962) summarized the above definition of technology diffusion using the following four core elements: (1) the technology that represents the new idea, practice, or object being diffused, (2) communication channels which represent the way information about the new technology flows from change agents suppliers (extension, technology suppliers) to final users or farmer, (3) the time period over which a social system adopts a technology and (4) the social system. Overall, the technology diffusion process essentially encompasses the adoption process of several individuals or farmers over time.

According to Feder *et al*. (1985), adoption can be categorized into individual or aggregate adoption. They defined individual adoption as the degree of use of a new technology in long- run equilibrium when the farmer has full information about the new technology and its potential, whereas aggregate adoption is defined as the process of spread of a technology within a region. Further, their studies distinguished technologies that are divisible and non-divisible. Divisible technology in terms of resource allocation requires the decision process to involve area allocations as well as levels of use of the rate of application (for instance, improved seed, chemical fertilizer, and bio-inoculant fertilizer).

Therefore, adoption of improved agricultural technologies such as improved chickpea variety, bio-inoculant and/or chemical fertilizer can therefore be categorized as divisible technology, defined as farmers who planted at least one improved chickpea variety and/or use chemical fertilizer for chickpea, and non-adopters are those who did not grow any of the improved chickpea variety and/or used chemical fertilizer in chickpea production.

2.1.3. Basic concepts of perception

According to Jeffrey Pickens (2005), perception is the process that organizes and interprets by our sensory in order to give meaning about the environment. It is the set of processes by which an individual become aware of and interprets information about the environment. The person interprets the stimuli into something meaningful based on their past experiences. However, an individual interprets or perceives may be different from reality. Van den Ban and Hawkins (1998) defined perception is a process by which we receive information or stimuli from our environment and transform it into psychological awareness. However, all innovations do not diffuse at the same rate. Various innovations are objectively differ and probably are perceived as being different by farmer decision maker. Thus, perception of differences would affect decisions to adopt or reject a particular innovation. Therefore, farmers receive and gather stimuli that indicate the attributes of improved chickpea technologies are superior over local and traditional one or not. Rogers (1983) has classified characteristics which may describe an innovation and individuals' perception, which predict their rate of adoption. These characteristics of innovations are: relative advantage to current tool or procedure, compatibility with the pre-existing system, complexity or difficulty, trial ability (testability) and observability of its effects. These qualities interact and judged as a whole.

2.2. Adoption decision theories

There are different categories of decision theories. According to Ndah *et al.* (2010) indicated that behavioral and cognitive theories are components of adoption decision theories in agriculture. Each of them could be defined as: behavioral theories are learning based on the idea that all behavior is through conditioning. It used in therapeutic settings to help clients learn new skills and behaviors. Cognitive theories are action is triggered through the uncomfortable tension which comes from holding two conflicting thoughts at the same time. It is focus on the internal state such as: motivation, problem solving, decision making and thinking condition.

In theories of psychological field, human behavior is a result of the interplay of different forces that make set circumstances through the dynamic interaction of human being and their environment. It also the interaction of situational forces with the perceived environment can be explained as a field of force, a system in tension or a psychological field (Ndah *et al*., 2010).

Theory of behavioral modification contains the inhibiting forces that negatively influencing behavioral change and the driving force that conductive to positive target of adoption. Behavior (adoption) is resulting from the psychological field of inhibiting and driving forces.

In the diffusion innovation theory, according to Rogers (1995) diffusion is the process by which an innovation is communicated through certain channels over time among the members of social system. Diffusion is a special type communication concerned with the spread of messages that are perceived as new ideas. The characteristics of an innovation, as perceived by the members of social system determine rate of adoption.

Technology users differ widely in their attitudes towards technology and their skills, ranging from early adopters who will master even the most difficult technology through to people who will never adopt. At bridge to technology we define technology adoption as a process that begins with awareness of the technology and progresses through a series of steps that end in appropriate and effective usage.

According to Borges *et al.* (2015), it is difficult to capture the complexity of farmers' decision. In the field of agricultural economics, farmers' decision and behaviors studied by two main different approaches: one is based on purely economic models, where expected utility theory (EUT) plays a central role. The other approach was based on socio-psychological theories, where psychological constructs explain farmers' behavior, that the decision to adopt an innovation.

Theory of rasoned action (TRA) or theory of planned behavior (TPB): The development of the TBP/TPA orginated in the field of social psychology. As early as 1862 psychologists began developing theories showing how attitude impacted behavior. The theory of planned behavior helps to understand how people's (adoption decision) behavior can be influenced. It predicts deliberate behavior, since behavior can be deliberate and planned. This theory assumes that human action to be guided by three things. These are behavioral, normative and control beliefs. Behavioral belief is the attitude towards the behavior and consequences of the behavior-adoption, normative belief is subjective norms and about the normative expectation of others and control belief is perceived behavioral control and express about the presence of factors that may facilitate or impede performance of behavior-adoption (Ndah *et al*., 2010). TBP does not cosider explict background factors, specially the role of acquistation of information/ learning process. However, EUT assume that that farmers' have the single objective of maximizing expected utility of profit (Borges *et al.,* 2015).

Expected utility theory (EUT): tells that the household chooses between risky or uncertain prospects by comparing their utility values. It states that a farmer compares the innovation with the traditional technology and adopts it if the expected improved technologies utility greater than the expected utility of the traditional technology (Batz *et al.,* 1999 as cited by Borges *et al.,* 2015). In this theory, there is Subjective Expected Utility Theory (SEUT) which is focus on uncertainty condition, and Von Neumann-Morgensern Theory (VNMT) in the case of risk condition. Von Neumann and Morgensern chose to determine the utility value of randomized strategy in mathematically convenient way (Philippe Mongin, 1998). EUT assumes that farmers have only the objective of maximize expected utility of profit. However, it does not consider social pressure on farmers to adopt an innovation. The combination of EUT and TRA/TPB avoid the above pointed restrictions. Considering both theories provide broad and compressive view on adoption decision.

The farmer households are influenced by the utility that they obtain as a result of making their own decision. Allying the theory that smallholder farm households are maximizing utility (the Von Neumann-Morgenstern's utility theory). The adoption decision is modeled in a random utility framework. The difference between the utility from adoption (U_{TECH_i}) and non-adoption (U_{TECH_i}*) of agricultural technologies (i= 1, 2, 3 represent improved chickpea varieties, bio-inoculant and chemical fertilizers, respectively) may be denoted as T_i*, such that a utility maximizing farm household will choose to adopt an improved chickpea variety, bio-inoculant and/or chemical fertilizer, if the utility gained from adopting is greater than the utility of not adopting ($T_i^* = U_{TECH_i} - U_{TECH_i}^* > 0$). Since these utilities unobservable, it can be expressed as a function of observable elements in the following latent variable model:

$$T_i^* = X'\beta + Z'\alpha + \varepsilon,\ T > 0\ \textit{if}\ Ti^* > 0$$

Where T_i* is a continuous indicator variable, represents adoption status and its level of improved variety, bio-inoculant and chemical fertilizer in chickpea crop production. The status of adoption is whether the farmer applied improved chickpea variety, bio-inoculant and chemical fertilizer in chickpea production or not, while the level of adoption is measured by calculating the proportion of cultivated land covered by technologies of the total chickpea cultivated land during 2015/16 production season, and β and α are vectors of parameters to be estimated; Z and X are vectors of explanatory variables; and ε is the error term.

2.3. Adoption studies in the world

From a sociological point of view, an innovation is an idea, practice, or object that an individual perceives as new. Since the focus is on the perception of the idea, the innovation need only be 'new' to the individual adopter. This indicates that adoption is the mental process from first hearing about an innovation to deciding to make full use of the new idea (Rogers and shoemaker 1971). Feder *et al.* (1985) argued, the sociological definitions of option are usually indicate for 'rigorous theoretical and empirical analysis' due to their inaccurate and limited to distinguish individual or farm level adoption from aggregate adoption.

From an economic point of view, an innovation is a technological factor of production that perceived and /or objective uncertainties about its impact on production. Farmers reduced uncertainty over time by getting good experiences, modifying the innovation, and becoming more efficient in its application. Therefore, economists have defined final adoption at farm level as the degree of use of a new technology in long run equilibrium when the farmer has full information about the new technology and its potential (Feder *et al.*, 1985).

According to Yigezu *et al.* (2015) adoption typically has been viewed from two perspectives. At individual farm level, each household chooses whether or not to adopt and the intensity of adoption. Farm level adoption studies, then, are concerned with the factors influencing the adoption decision either statistically or dynamically by incorporating learning and experience. At macro level, diffusion studies examine how adoption involves across a population or region. Since the objective is to identify specific trends in the diffusion cycle over space and time, diffusion models do not explicitly address the innovation process.

According to Feder *et al.* (1985) summarized empirical literature on adoption of new technology and production at household level constrained may arise from different sources, such as limited land size, access of credit availability, risk and uncertainty related to the technologies and availability of cash resources. Socio-economic, demographic, institution factors and subjective perception were determined the new agricultural technologies adoption (Akinwumi and Jajo, 1995).

A common drawback of previous empirical analysis of innovation adoption was dichotomous terms (adoption/ non-adoption) and multinomial qualitative choice models established in the adoption literature even though the actual decisions made by farmers are defined over a continuous range (Feder *et al.,* 1985). The purpose of qualitative choice models is to determine the probability of an individual with a given set of attributes will make one choice than an alternative (Green, 2003). The two most popular functional forms used for adoption models are the Probit and the Logit models.

Ghadim and Pannell (1999) cited Linder (1987) indicated that four major problems for the inconsistent results obtained by most of the empirical studies of agricultural innovations such as failure to account for the importance of the dynamic learning process in adoption, Biases from omitted variables, poor model specification, Failure to relate hypotheses to a good conceptual framework. They also assumed that previous adoption models did not substantially consider the dynamic technology adoption decision model, such as farmers' personal perception, managerial abilities and risk preferences.

Dimara and Skuras (2003) and Yigezu *et al.* (2015) model depicts adoption as a multistage decision process by violating full information assumption that incorporates information acquisition and learning by doing by farmers who vary in their risk preference and perceptions of the risks associated with the innovation.

In recent studies involves multiple stages and the decision may be independent or sequential for the determinants of technology adoption and intensity by farmers indicated by Ibrahim *et al.* (2012) used Hackman two-stage model, Huang *et al.* (2015), Akalu *et al.* (2016) used ordered Probit model, and Yigezu *et al.* (2015) multivariate Tobit and Probit models. They indicated the magnitude and direction of influence of factors hypothesized to condition technology adoption for their area specific and their importance varied among regions, agro-ecologies and site specific.

Most of adoption studies in Ethiopia focused on estimating of improved wheat and maize technologies and complementary inputs such as fertilizer and herbicides on smallholder farmers. Few studies were exerted to assess the adoption of soil and water conservation technologies. Technology package adoption was also very limited study in the country. Most of the econometric models developed and used to investigate the technology adoption decision behavior of smallholder with limited explanatory variables and single step were used.

Many of study in Ethiopia except Solomon *et al.* (2011) and Tesfaye *et al.* (2014) used Tobit model for technology adoption analysis. In the Tobit model, decisions whether or not to adopt and how much to adopt the technology are assumed to be jointly and hence the factors that determine the two decisions are taken to be the same.

Hence this study argues that of individual farmer in technology adoption decision and level of use of technology decision affected by external factors that influence the two decisions. In addition, farmers who have more information and knowledge about improved technologies; they are confidential to expand technology usage from the simple plot to the maximum land coverage of chickpea production.

2.4. Chickpea production and research in Ethiopia

Chickpea (*Cicer arietinum* L.) was first produced in the Middle East about 7,000 years ago. At present, it is cultivated in above 40 countries of the globe around 11 million ha of land from which over 8 million tons of seed is yearly harvested (Menale *et al*., 2009). The major producers are India, Pakistan, Turkey, Australia, Iran, Myanmar, Canada, Ethiopia, Mexico and Iraq with over 93% of the global production. In Africa, chickpea is widely grown in Ethiopia, Sudan, Eritrea, Kenya, Tanzania and Malawi. It contributes around 63% of the total production in Africa. In Ethiopia, chickpea ranks third in area coverage from among the pulses grown areas and proceeded by Faba bean and Field pea and second in volume of production only next to Faba bean. In the country, with a total area of 229,720.74 ha land and the productivity of 1.85 ton per hectare (CSA, 2014; TL-III, 2016).

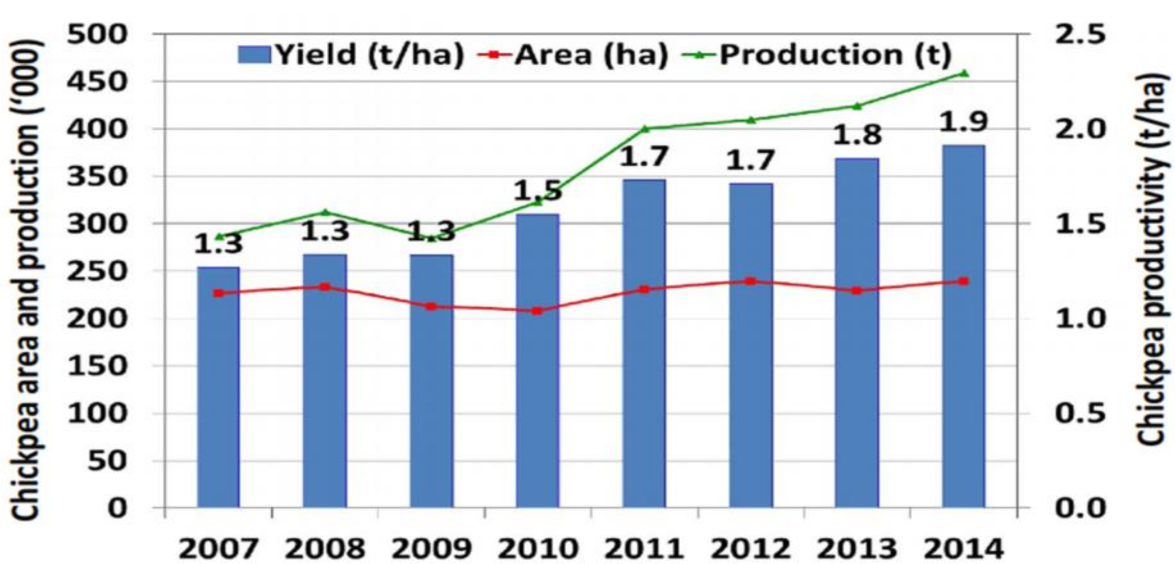
Chickpea is considered less labor-intensive crop and its production requires less external inputs as compared to cereals. It is widely grown around the world and serves as a multi-use crop. It plays a significant role in improving soil fertility by fixing the atmospheric nitrogen. It can fix up to 140 kg nitrogen per hectare from air and meet most of its nitrogen requirement. After harvest, it leaves substantial amount of residual nitrogen for subsequent crops and adds some amount of organic matter to maintain and improve soil health and fertility. This saves the fertilizer input cost not only for chickpea but also for the subsequent crops. Chickpea has the ability to grow on residual moisture which gives farmers the opportunity to engage in double cropping, where chickpea is sown at the end of the rainy season following the harvest of the main crop. This allows more intensive and productive use of land, particularly in areas where land is scarce. It is also an excellent source of protein, fiber, complex carbohydrates, vitamins, and minerals thus can help alleviating malnutrition and improving human health. The growing demand in both the domestic and export markets provides a source of cash for smallholder producers (Million and Asnake, 2011).

Chickpea research was started at *Debre zeit* Agricultural Research Center to contribute for increased productivity, insuring sustainability of production, and to improve the economic and social welfare of farmers. Diseases and insects, limited use of modern inputs, and inappropriate agronomic practices were found to constrain productivity of chickpea. Lack of market incentives and postharvest losses are also important problems of chickpea production (Legesse *et al.,* 2005).

In the last 30 years many different varieties of chickpea were released from research centers. The availability of improved seed varieties from agricultural research centers has facilitated the release of varieties since the 1990s. These include *Shasho, Arerti, Chefe, Ejere, Teji, Habru, Akaki and worku* improved chickpea varieties. Generally, Desi and Kabuli types are the two major types of chickpea grown in the world with major differences in seed size, seed color, surface and thickness of the seed coat. The Desi type is characterized by small seeds with angular appearance, sharp edges and varying colors but usually light brown. On the other hand, the Kabuli type produces large round seeds of white or pale cream or yellow color (Legesse *et al.,* 2005; Solomon *et al.,* 2011). Desi-type is a small dark seeded with rough coat, fairly drought tolerant, adapted to low rainfall areas and is of shorter height. It account for about 10% of the world's current production. Kabuli-type is a lighter color, late maturity type with a thin white seed coat and is found mainly in areas of good rainfall. It is relatively taller height, larger seed size and smoother coat.

Different studies in different countries indicated that improved chickpea variety, and chemical fertilizer with Rhizobium inoculation were significant increment (8 to 40%) on grain yield and up to 60% Stover yield. Studies in Ethiopia specifically in Oromia, Gondar and in southern part of the country indicated that inoculant was strong response for chickpea crop (N2Africa, 2013).

Figure 1. Chickpea area, production and yield in Ethiopia during 2007 - 2014.



Source: CSA, 2014 and TL-III, 2016 reports.

2.5. Empirical studies on factors influencing adoption

There are literatures on adoption of high yielding varieties and management of technologies both abroad and inside the country. Studies indicated that, the adoption decision of farmers are affected by a number of variables such as demographic, economic, social and networking, communication and information, behavioral and institutional variables.

Demographic variables: are among the most important household characteristics that influence technology adoption decision. Sex, age, education level, and active family labors are the major factors that influence improved technology adoption. In developing countries due to cultural and social grounds, women have less access to institutional, information and communication services. Concerning the relationship household sex to technology adoption, many previous studies showed that positive relationship with technology adoption in favor of male households. According to Simtowe *et al*. (2011) studies on determinants of agricultural technology adoption, males house headed were more adopters of technology than females. However, Solomon *et al.* (2010) reported that gender differential was not effect on technology adoption. In addition, according to Ibrahim *et al*. (2012) study on the determinants of farmer adoption of improved peanut varieties and their impact on farm income reported that gender was not significance difference on technology adoption. Solomon *et al.* (2011) reported that age and gender of the household head have no significance difference on the agricultural technology adoption. According to Huang *et al.* (2015) on the study of adoption intensity of agricultural technology indicated that there was not significance difference in gender between adopters and non-adopters of the household heads.

The age of the household head one of the factors that influenced the adoption of technology. It is incorporated as it is believed that with age, farmers accumulate more personal capital and thus, a greater chance of investing in innovations. However, it may also be that younger household heads are more flexible and hence likely to adopt new technologies. According to Huang *et al.* (2015) on the study of adoption intensity of agricultural technology indicated that Youngers are more technology adopters than elders. According to Langat *et al.* (2013) on the study of drivers of technology adoption in a subsistence economy reported that age had significant effect on the technology adoption. However, according to Akalu *et al.* (2015) on the study of House-Level determinants of soil and water conservation adoption phases indicated that age not significant effect on the stage of adoption. Similarly, Simtowe *et al.* (2011) study on the determinants agricultural technology adoption in the case of improved pigeon pea varieties in Tanzania reported that age was not significant influence on adoption. In addition, Adam Bekele and Yitayal Abebe (2014) indicated that age was negative and significant factor for technology adoption.

Education is associated with the technology adoption because of it is assumed that increase farmers' ability to obtain and analyze information that helps him/her to make appropriate decision. According to Huang *et al.* (2015) on the study of adoption intensity of agricultural technology indicated that education is positive and significant effect on the technology adoption. According to Langat *et al.* (2013) on the study of drivers of technology adoption in a subsistence economy indicated that education level of head of household was found to favor adoption of tissue culture banana compared to their counterparts with less schooling. However, Simtowe *et al.* (2011) study on the determinants agricultural technology adoption in the case of improved pigeon pea varieties in Tanzania reported that education was not significant influence on adoption. In addition, according to Solomon *et al*. (2010) and Ibrahim *et al*. (2012) studies reported that education was not significance difference on technology adoption.

Active family labour is also one of important variable for the technoloy accepting easilly. According to Solomon *et al.* (2011) on the study of agricultural technology adoption, seed access constraints and commercialization in Ethiopia that reported, active family labour force had positively significant effect on the level of improved chickpea varities adoption. However, Simtowe *et al.* (2011) on the study of the determinants agricultural technology adoption in the case of improved pigeon pea varieties in Tanzania reported that labor was not significant effect implying that labor was not constraint for farmers to adopt improved varieties of pigeon pea. According to Huang *et al.* (2015) on the study of adoption intensity of agricultural technology indicated that there was not significance effect on the technology adoption.

Economic variables: are very important for agricultural technology adoption. These are total land holding, on farm and off farm incomes, total livestock and number of plots of land. Land related variables are influence household adoption decision. Solomon *et al.* (2011) reported on the agricultural technology and adoption, seed access constraints and commercialization in Ethiopia study that amount of land owned by household head was significance effect on adoption decision. Akalu *et al.* (2015) on the study of house-level determinants of soil and water conservation adoption phases indicated that average parcel size had a positive and significant effect on actual and final stages of SWC adoption. Similarly, Menale *et al.* (2010), Solomon *et al.* (2011), Legesse *et al.* (2005) and Langat *et al.* (2013) reported amount land holding had a positive and significant effluence on adoption decision.

Farm income is one important variable for adoption decision. The amounts of household income obtain from the sale of crop and animal, after household consumption met helps to purchase agricultural inputs. According to Almaz Giziew (2008) and Solomon *et al*. (2011) reported that household income had a positive and significant effect for technology adoption decision. However, in the study of Simtowe *et al*. (2011) reported that income no significance effect on technology adoption.

Livestock size is an important indicator of households' wealth position. Livestock are also important source of generating income that helps to purchase agricultural inputs. Usually it has a positive association with technology adoption decision. According to Solomon *et al*. (2011), Huang *et al.* (2015) and Simtowe *et al*. (2011) reported that livestock ownership had positive and significant result for technology adoption decision than these who had not livestock. Howevere, Adam Bekele and Yitayal Abebe (2014) indicated that Livestock ownership had a significant effect on delaying technology adoption.

Institution and infrastructural: are important factors for technology adoption decision. They are access to credit, distance to main market, distance to office of agriculture, and distance to main road.

Access to credit is very important for technology adoption. Capital is one of best ingredients for Agricultural production. Most of studies such as according to Negera Eba and Getachew Bashargo (2014), Berihun *et al.* (2014) and Ogada *et al*. (2014) reported that credit had a positive and significant influence of household head technology adoption decision. However, Simtowe *et al*. (2011) revealed that access to credit had insignificant effect on adoption of technology.

Distance to main market, distance to main road and distance to agricultural office are usually inversely affected for technology adoption decision. Menale *et al.* (2010), Adam Bekele and Yitayal Abebe (2014), Negera Eba and Getachew Bashargo (2014), Ogada *et al.* (2014) and Berihun *et al.* (2014) indicated in their study that, these variables had a negative and significant effect on the decision of technology adoption for household head.

Socio-cultural: variables are influence households' Agricultural technologies adoption decision. In this Study, variables are member of cooperative, member of cultural and religious association, member of administrative and cosmopolitans.

Farmer association member was indicated by Berihun *et al*. (2014) and Menale *et al.* (2010) that there was positive and significant factor for agricultural technology adoption. In addition, Huang *et al.* (2015) found that the higher the participation of farmers in groups and local cooperative, the more the household head adopted the improved seeds. However, Solomon *et al*. (2011) and Berihun *et al.* (2014) revealed that farmers association did not significant factor for technology adoption decision.

A cosmopolitan is the degree of contact of a farmer with external situation of the social system. This is believed to influence the access to information on improved farming practices as compared to other members of the group and influence adoption positively. According to Almaz Giziew (2008) it was not significantly influenced for technology adoption.

Household's information and communication factors: is one category of the variables which are mostly associated with farmers' adoption behavior. These are radio, mobile, extension service and attendance extension events (Field day and training).

Extension service one of the most important factors for technology adoption. Negera Eba and Getachew Bashargo (2014), Huang *et al.* (2015), Arslan *et al.* (2013), Solomon *et al*. (2011) and Adam Bekele and Yitayal Abebe (2014) studies indicated that extension service was a positive and significant factor for technology adoption decision. However, Ibrahim *et al*. (2012) study on the determinants of farmer adoption of improved peanut varieties and their impact on farm income reported that extension service had not a significance difference on technology adoption.

Radio and mobile are important tools for technology adoption and diffusion. Solomon *et al*. (2011) revealed that radio and mobile ownership had a positive and significant effect on technology adoption. However, Simtowe *et al*. (2011) showed that radio and TV had not statistically significant effect on technology adoption decision.

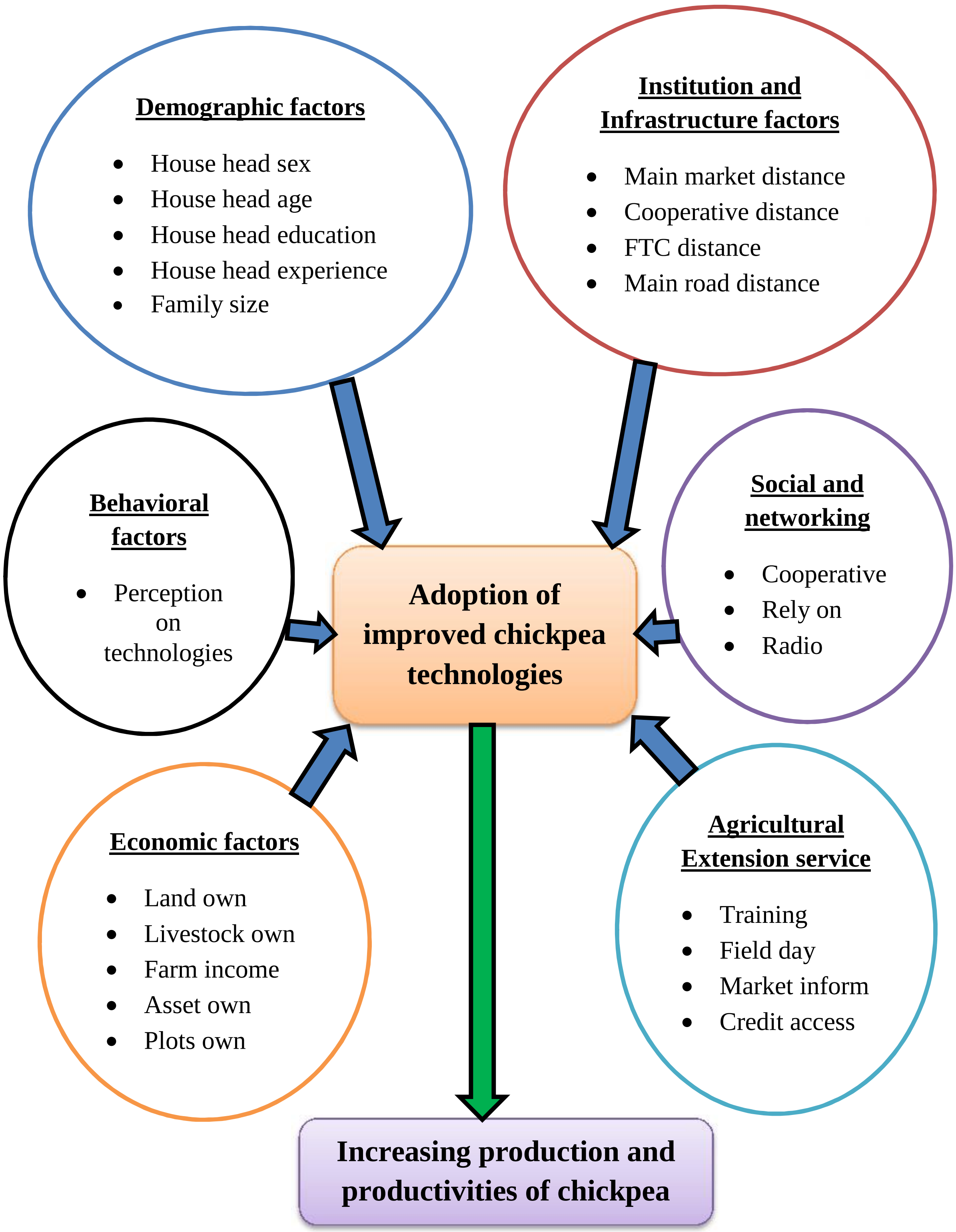
Attendance on extension events is very necessary for decision of technology adoption. Almaz Giziew (2008) and Simtowe *et al*. (2011) showed that significant effect of this variable on technology adoption.

Perception with the way the attribute of innovation is perceived and the respondent's perception of the technology attribute. According to Akalu *et al.* (2015) on the study of house-level determinants of soil and water conservation adoption phases indicated that farmers' perception about soil erosion had a significant effect on adoption of soil and water conservation practices.

2.6. Analytical framework of the study

Several literature, practical experiences and observations of the reality have indicated that one factor may facilitate adoption of technology in one area and time. However, it also may hinder in another situation. Therefore, it is difficult to develop specific and unified adoption model in technology adoption process because of the economic, social and networking, behavioral and infrastructure variation of different areas, and also various natures of determinant factors. This study is based on assumption that a number of factors influence adoption of improved chickpea technologies. These factors are demographic, economic, social capital and networking, information and communication, institutional and behavioral variables.

Table 1. Conceptual framework of adoption



Source: Own, based on literature review, 2017

3: RESEARCH METHODOLOGY

This chapter discusses how the research is conducted. This section consists of description of study area, sampling procedure and sample size determination, methods of data collection, methods of analysis and defections of variables and hypotheses.

3.1. Description of study area

The Federal Democratic Republic of Ethiopia is administratively divided into nine national regional states and two administrative councils. The Amhara National Regional State (ANRS) is one of the nine regional states. The ANRS is again divided into eleven administrative zones, one of which is North Gondar.

Gondar Zuria is one of the 21 Districts of North Gondar Administrative Zone. *Gondar Zuria* shares borders with *Wogera* and West *Belesa* districts in the North, with *Lay Armachiho* in the West, with *Dembia* district and Lake Tana in the South and *Libo kemikem* District in the East. *Gondar Zuria* is divided into 35 rural *kebeles* and 3 urban *kebeles.* As estimated by the District Office of Agriculture (DOA), this District has an area of 114,983 hectares. Topography of the district's area is 65% flat land, 25% hill and 10% valley type. *Gondar Zuria's* area coverage 63% is for cropland, 14.8% grass land, and 9.6% is covered with forest, 7.5% is taken by physical constructions, 2.6% of is regarded as wasteland and 2.5% for other.

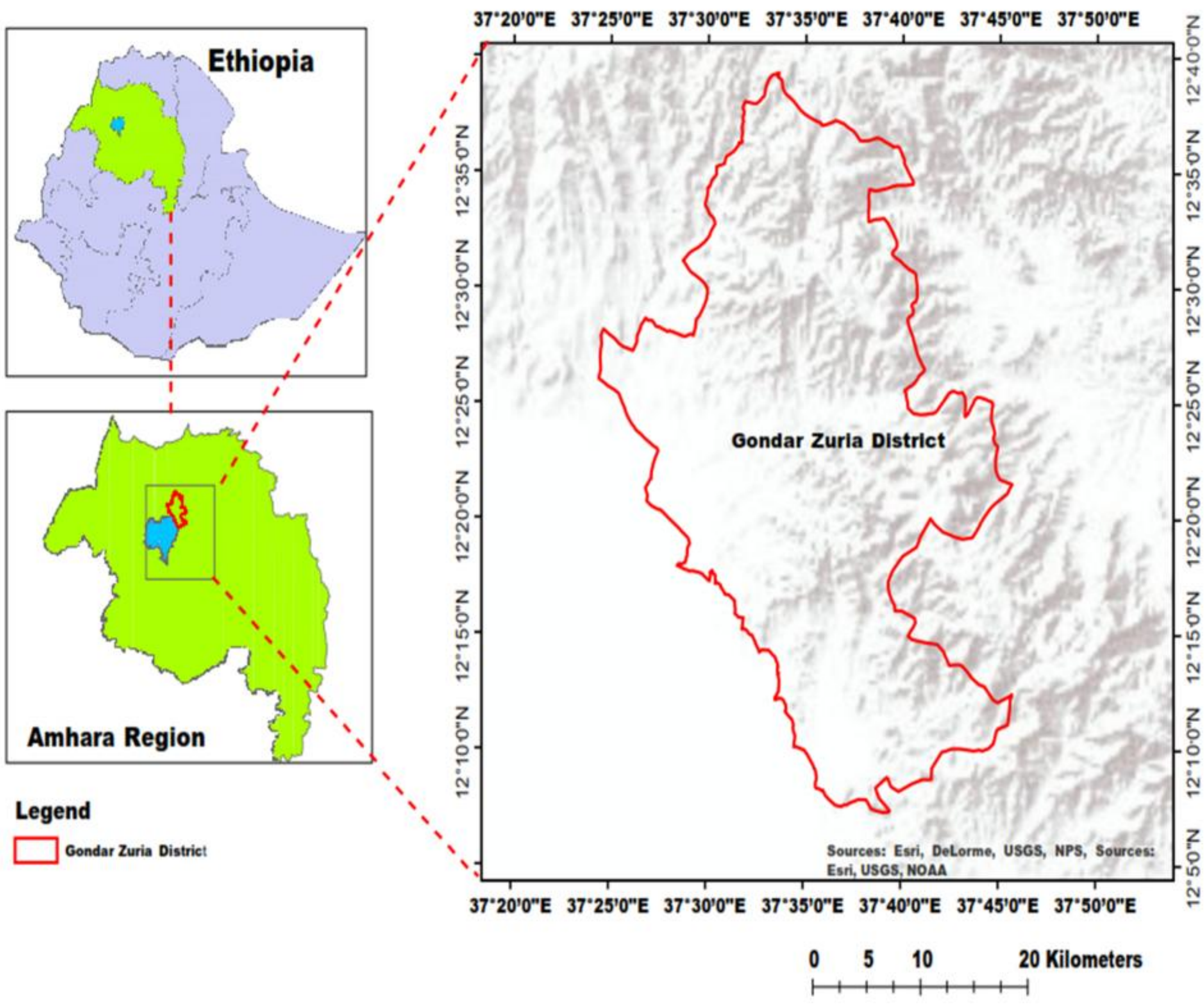
Based on traditional agro-ecological classification, *Gondar Zuria* is described as 22 % *Dega* and 78% *Woina Dega*. The annual average rainfall of the district ranges from 950 to 1035 mm. The yearly average temperature also ranges in between 24 – 33 C^0. The altitude of the District ranges from 1800 to 2700 m.a.s.l. (*Gondar Zuria* DOA, 2017).

The District had a human population of 224,460 with 113,702 (or 50.6%) males and 110,758 (or 49.4%) females based on CSA projection (CSA, 2014). In addition, 87.2% of *Gondar Zuria's* population lives in rural areas while the remaining lives in *Makisegnit*, *Enferaz* and *Degoma* towns (CSA, 2014).

As specifically related to farming life, the ever-increasing population overstocks the limited land resource. The total population density of *Gondar Zuria* district was found to be about

203 persons per Km^2 while the agricultural density, considering both crop and grazing lands regardless of slope, was 250 persons per Km^2. This shows that there is high population, which should be seen from the high subsistence requirement and the limited sources of earnings. Hence, using improved technology is a gear to escape from poverty. It has high potential of chickpea production and arable land coverage. In the district, improved technologies were demonstrated and popularized in the previous years.

Figure 2. Map of *Gondar Zuria* District



Source: GIS shape file of Ethiopian administrate map

3.2. Sample size determination and Sampling procedure

A multi-stage sampling procedure was used to select district, *kebeles* and farmers. In the first stage of sample procedure was purposive selection of *Gondar Zuria* district. The district was selected purposively because of intensity of chickpea crop production, agro-ecological suitability and accessibility. In addition, Gondar Agricultural Research Center and non-governmental organizations (e.g N_2 Africa, TL-II and ICARDA projects) in collaboration with district office of agriculture, cooperative and unions generated, demonstrated and promoted chickpea technologies in *Gondar Zuria* district in previous years. *Gondar Zuria* district is stratified as potential *kebeles* for chickpea crop production and others not. *kebeles* were about 17 identified for their good potential for chickpea crop production. *Kebele* administritives were stratified into chickpea crop growing and non-growing *kebeles*. As the second stage of sampling procedure, a total of four kebeles namely *Tsion-segaje*, *Bahiri-gimib*, *Zengaj* and *Degola-chinichaye* were selected randomly from chickpea growing potential kebeles that included *kebeles* from far and near distance from the main town of district. As the thrid stage of sampling procudure respondets were selected using simple random sampling in the selected *kebeles*. The respondents from each selected kebeles were identified using probablity proportional to size random sampling technique. The respondent farmers were both male and female household heads in the selected *kebeles*.

Table 2. Description of sampled *kebeles*

Kebele	Household population			Total population			Chickpea area
	M	F	T	M	F	T	(ha)
Tsion-segaji	543	174	717	2186	2102	4288	210
Bahiri-gimib	719	91	810	2472	2282	4754	310
Zengaj	655	117	772	2348	2291	4639	380
Degola-chinichaye	1080	146	1226	3906	3578	7484	235
Total	2997	528	3525	10912	10253	21165	1135

Source: *Gondar Zuria* District, Office of Agriculture report, 2016.

A representative sample size, for cross-sectional household survey and known population the study employ the sample size determination formula given by (Kothari, 2004). Finally the sampled household heads were selected using probability proportional to size from each *kebele* that makes a sample size of 224 household heads, which is estimated by the following equation (1), sample of household heads were randomly selected from the selected *kebeles* using probability proportion to size. The case study was included interviews with 15 farmers, 4 development agents and 2 focus group discussions (FGD). Using survey interview instrument 224 household heads were interviewed in selected *kebeles*.

$$n = \frac{z^2 pqN}{e^2(N-1)+z^2 pq} \quad (1)$$

Where:

n= Sample size for a finite population

N= Size of Population which is the number of households in districts

P= Population reliability (or frequency estimated for a sample of size n), where p is 0.2

e= margin of error considered is 5 % for this study.

$z_{\alpha/2}$ = normal reduced variable at 0.05 level of significance z is 1.96

Table 3. Proportional sample size

Sampled *kebeles*	No. of chickpea producer farmers	Sample size
Tsion-segaji	638	57
Bahiri-gimib	605	54
Zengaj	571	51
Degola-chinichaye	694	62
Total	2508	224

Source: Own computation, 2017

3.3. Methods of data collection

To undertake this study, cross-sectional survey involving both qualitative (focus group discussion, key informant interview, and spot observation using checklists) and quantitative using semi-structure interview schedule was employed. To collect required data for this particular study, both primary and secondary source of data were used. The primary data were collected using semi-structure interview schedule, focus group discussions and key informant interview methods. The secondary data were gathered from secondary sources such as published and unpublished documents. The documents were collected from North Gondar Agricultural Development Department, District office of Agriculture, Gondar Agricultural Research Center.

A formal survey instrument was prepared and data were collected by trained enumerators from randomly selected household heads using semi-structured interview schedule. The interview for the formal survey was tested on farm with household heads. These were interviewed by using semi-structured interview for this specific study. The questions were forwarded to 224 household heads were randomly selected from 4 rural *kebeles* namely, *Tsion-segaji*, *Bahiri-gimib*, *Zengaj* and *Degola-chinichaye* in the study district.

3.4. Methods of data analysis and Model specification

The information gathered from different sources was compiled. The quantitative data were entered in STATA version 13 and SPSS version 20 statistics tools for analysis. The result of analysis were interpreted and discussed in using descriptive statistics and econometrics models. The data were obtained from focus group discussion and key informant interview were analyzed by qualitatively.

3.4.1. Descriptive statistics

Descriptive statistics was employed to analyze data by using mean, percentage, standard deviation, chi-square test and t-test. It gives a summary of statistics related to variables of interest. Chi-square test and an independent sample t-test were applied used to identify variables that vary significantly between adopters and non-adopters. The chi-square test was conducted to compare some qualitative characteristics of adopters and non-adopters. The t-test was used to observe if there is statistically significant difference between mean of respective adopter and non-adopter categories with respect to continuous variables.

3.4.2 Econometric analysis

3.4.2.1 Adoption status of improved chickpea technologies

Probit Model: In the Probit model, household heads are assumed to make decisions based upon an objective of utility maximization. For a given decision, separate models are developed for each decision. The underlying utility function depends on household specific attributes X and a disturbance term having a zero mean:

$$U_{i1}(w) = \alpha_1 w_i + \varepsilon_{i1} \quad \text{for adoption} \qquad (2)$$

and $U_{i0}(w) = \alpha_0 w_i + \varepsilon_{i0}$ for non-adoption (3)

as utility is random, the i[th] household head selects the alternative “adoption” if and only if $U_{i1} > U_{i0}$. Thus, for the household i probability of adoption is given by:

$$P(1) = P(U_{i1} > U_{i0}), \quad P(1) = P(\alpha_1 w_1 + \varepsilon_{i1} > \alpha_0 w_1 + \varepsilon_{i0}), \tag{4}$$

$$P(1) = P(\varepsilon_{i0} - \varepsilon_{i1} < \alpha_1 w_1 - \alpha_0 w_1) \tag{5}$$

$$P(1) = P(\varepsilon_i < \alpha w_i) \tag{6}$$

$$P(1) = \Phi(\alpha w_i) \tag{7}$$

Where Φ is cumulative distribution function of standard normal distribution. The parameters α are estimated by maximum likelihood w is a vector of explanatory variables which explains adoption. In case of normal distribution function, the model to estimate the probability of observing a farmer using a new technology can be stated as:

$$P(y_i = 1/w) = \Phi(w'\alpha) = \int_{-\infty}^{w'\alpha} \frac{1}{\sqrt{2\Pi}} \exp(-z^2/2)dz \tag{8}$$

Where P is the probability that the i[th] household used new technology and 0 otherwise. The Probit model is generated by a simple latent model of the form shown below in equation.

$y^* = w'\alpha + \varepsilon$ Where ε / w is a normally distributed error term. (9)

The Tobit model

Tobin (1958) was the original model developed to analyze censored dependent variables. In the Tobin model censoring is assumed to represent a standard corner solution. It assumes the same variable affect the probability of a non-zero observation (adoption decision) as well as the level of positive observation (the amount of land for the technology decision) and moreover with the same sign.

$$y_i^* = x_i \beta + \varepsilon_i \tag{10}$$

$$y_i = 0 \quad \text{if } y_i^* \leq 0 \tag{11}$$

$y_i = y_i^*$ if $y_i^* > 0$ (12)

$\varepsilon_i \sim N(0, \delta^2)$ (13)

Where, Φ and ϕ are the standard normal cumulative distribution function and density function.

Where y_i^* is a latent endogenous variable representing household adoption decision, y_i observed dependent variable (level of land use by improved chickpea technologies), x_i is a set of individual characteristics explaining the adoption decision, x_i is variables explaining the level of improved chickpea technology adoption decision and ε_i is independent, homoscedastic, normally distributed error terms.

The likelihood function for Tobit model

$$L(\beta, \sigma) = \prod_{y_i=0} 1 - \Phi\left[\frac{x_i'\beta}{\sigma}\right] \prod_{y_i>0} \frac{1}{\sigma} \phi\left[\frac{y_i - x_i'\beta}{\sigma}\right] \quad (14)$$

The impacts of the regressors on the dependent variable, marginal or partial effects are calculated by using maximum likelihood results. The overall effect values of the explanatory variables x on the dependent variable is expected value of y_i. In the Tobit model and its various generalizations, this is more commonly known as the unconditional expectation of y_i is written as $E[yi/x]$. The unconditional expectation can be decomposed in to two parts, the conditional expectation $E[y_i/y_i > 0, x]$ which is the expected value of y_i for values of the explanatory variable x, conditional of $y_i > 0$ and the probability of a positive value of y_i for values of the explanatory variable, x, $P[y_i > 0/x]$.

The decomposition of the unconditional expectation into the probability of adoption and conditional expectation is based on the study by Eakins (2014), decomposition of the unconditional mean of the dependent variable in the Tobit model and can be summarized by the following equation:

$$E[y_i/x] = P[y_i > 0/x] * E[y_i/x, y_i > 0] \quad (15)$$

The marginal effect can be calculated by differentiating each of the above equation with respect to each explanatory or independent variable.

$$\frac{\partial \mathrm{E}[\mathrm{y}_i/\mathrm{x}_i]}{\partial \mathrm{x}_i} = \beta_j * \Phi[\frac{x_i{'}\beta}{\sigma}] \qquad (16)$$

3.4.2.2 Levels of adoption of improved chickpea technologies

Ordered Probit model

In order to estimate level of adoption of improved chickpea production package (improved seed, bio-inoculant fertilizer and chemical fertilizer (DAP)), adoption index of individual farmer was calculated as follows.

$$AI_i = \sum_{i=1}^{n} \frac{\left(\frac{AC_i}{AT_i}+\frac{AB_i}{AT_i}+\frac{AF_i}{AT_i}\right)}{NP} \qquad (17)$$

Where:

AI_i = Adoption index of the ith farmer, $i = 1$, 2, 3…….n and n= individual respondent farmers

AC_i = Area under improved chickpea variety by ith farmer

AB_i = Area under bio-inoculant fertilizer for chickpea production by ith farmer

AF_i = Area under DAP fertilizer for chickpea production by ith farmer

AT_i = Total area allocated for chickpea crop production (improved + local chickpeas) by ith farmer. NP = Numbers of practices

The adoption index was changed into different adoption index range of levels (Non-adopter = 0, Low adopter = 0.01- 0.33, Medium adopter = 0.34 - 0.66 and High adopter = 0.66 - 1.00)

In statistics, ordered probit is a generalization of popular probit analysis to the case of more than two outcomes of an ordinal dependent variable. Similarly, popular logit method also has a counterpart ordered logit.

According to Akalu *et al*. (2015) study indicate that there some multinomial choice factors exist ordered, for instance soil and water conservation measures of adoption phases which includes initial adoption, actual adoption and final adoption. Similarly, adoption of chickpea technology package may not accept technology instantaneously in one time, rather the farmers accept in stages of ordered way. The model cannot be consistently estimated using ordinary least square: it is usually estimated using maximum likelihood. Following Green (2003), Ordered Probit model can be determined by

$y_i^{*}= x_i^{T}\beta + v$, i= individual 1…..N Farmers, (18)

Where, i refer to the observation (a farmer), y_i^{*} is latent or index but unobserved dependent variable that represent adoption stages or phases farmer i. x_i is vector independent variables, and β is vector of regression coefficient which we wish to estimate v are the random error terms assumed to be standard normal distributed. Further suppose we have N independent individuals (Observations) and we face three alternatives for level of adoption, such as:

$y_i= 0$ (Non-adopters) (19)

$y_i= 1$ (Low adopters) if $0 < y_i^{*} \leq \mu_1$ (20)

$y_i= 2$ (Medium adopters) if $\mu_1 < y_i^{*} \leq \mu_2$ (21)

$y_i= 3$ (High adopters) if $\mu_2 < y_i^{*} \leq \mu_3$ (22)

Where $\mu_1 < \mu_2 < \mu_3$

That is, we observe an individual y_i in one of the J ordered categories, these categories being separated by the threshold parameters or cutoffs, the μs. In other words, the threshold parameters demarcate the boundaries of the various categories. The μ_j s is unknown ordered threshold parameters to be estimated with the unknown coefficients β. The probabilities that the ordered dependent variable y takes the different possible value are

Prob (y=0/X) $=\Phi(-X'\beta)$ (23)

Prob (y=1/X) $=\Phi(\mu 1 - X'\beta) - \Phi(-X'\beta)$, (24)

Prob (y=2/X) $=\Phi(\mu 2 - X'\beta) - \Phi(-X'\beta)$, (25)

Prob (y=3/X) $=\Phi(\mu 3 - X'\beta) - \Phi(-X'\beta)$, (26) Where Φ indicates a cumulative normal distribution. The cut-points μ_j divide the categories of the dependent variable.

The marginal effect is used to determine the influences of independent variable per unit change on the dependent variable other things are constant. Computation of marginal effects is meaningful for the ordered probit model because estimated parameter coefficients do not represent the magnitudes of the effect of independent variable on the categorical of dependent variable. Therefore, the marginal effects of changes in the repressors are

$$\frac{\partial \text{ pr } (y=0/X)}{\partial X} = -\Phi(X'\beta)\beta \quad (27)$$

$$\frac{\partial \text{ pr } (y=1/X)}{\partial X} = [\Phi(-X'\beta) - \Phi(\mu 1 - X'\beta)]\beta \quad (28)$$

$$\frac{\partial \text{ pr } (y=2/X)}{\partial X} = [\Phi(\mu 1 - X'\beta) - \Phi(\mu 2 - X'\beta)]\beta \quad (29)$$

$$\frac{\partial \text{ pr } (y=3/X)}{\partial X} = [\Phi(\mu 2 - X'\beta) - \Phi(\mu 3 - X'\beta)]\beta \quad (30)$$

The parameter of the ordered probit model is estimated by the maximum likelihood method. We report the marginal effects of the variables. The sign of the regression parameters β can be immediately interpreted as determining whether the latent variable y^*, increases with the regressor. If β is positive then an increase in x_i necessarily decrease the probability of being in the lowest category (y_i =1) and probability of being in the highest category (y_i =3).

3.4.2.3 Estimation of chickpea technologies preference and perception

The estimation for the coefficients was done through multiple linear regression models to determine utility value of each attribute level. The basic conjoint model in the research was represented (Shalini and Msood, 2010) as: Total Utility = Sum of all partial utilities.

$$\text{U(X)} = \sum_{i=1}^{m} \sum_{j=1}^{ki} \alpha_{ij} x_{ij} \quad (31)$$

Where

U(X) = overall utility (importance) of an attribute

α_{ij} = part-worth utility j^{th} level of the i^{th} attribute

$i = 1, 2 \ldots\ldots m \quad j = 1, 2 \ldots\ldots k$

X_{ij} = 1, if the i^{th} attribute and j^{th} level is present in a profile

= 0, otherwise

The preference judgment is an approximately interval scale, then the part-worth can be presented by dummy variables and ordinary least squares (OLS) regression is a natural and relatively straight forward means with which to estimate the part-worth.

The measures of attribute levels are independent variables. The estimated coefficients associated with the independent variables are the preference scores for the levels. The coefficients are utility estimate (part-worth) of the attribute levels.

In the conjoint analysis, the part worth model is the model used to express the utilities or the measure of desirability of the various attribute levels this can be estimated with different techniques such as ordinary least square regression analysis and logistic regression. Bard *et al.* (2002) found that multiple linear regressions were appropriate estimation method in conjoint analysis. If the preference judgment is an approximately interval scale, the part-worth can be represented by dummy variables and multiple linear regression is a means with which to estimate the part-worth utility (Hauser and Rao, 2002). For this study, multiple linear regression models that used are specified as follows.

$$Y_i = \beta_0 + \beta_1(\text{Arerti}) + \beta_2(\text{Shasho}) + \beta_3(\text{Natoli}) + \beta_4(\text{DAP fertilize}) + \beta_5(\text{Bio-inoculant}) + \beta_6(\text{50 \% pre-payment}) + \beta_7(\text{Age}) + \beta_8(\text{Radio}) + \beta_9(\text{Farm income}) + \beta_{10}(\text{Credit access}) + e \qquad (32)$$

Where: Y_i = represents the rating value given by respondent "i" on the five point likert scale.

The conjoint methodology is a decomposition approach to analyze consumer preferences. Respondents give an overall score (a real score in the rating approach or an implicit score in the ranking approach) to a product profile and the analyst has find out what the preference contributions are for each separate attribute and level, where it is commonly assumed that the overall utility of a profile is constructed by adding the attributes preferences. This means that a compensatory preference model is used, where ‘’low” scores on certain attribute can be compensated by “high” score on another attribute. In conjoint experiments the contribution of an attribute (level) to the total utility is called a "part-worth" and the total utility of a profile in a compensatory, additive preference model is equal to the sum of the part-worth:

$$U = \sum_s X_s \beta_s \quad (33)$$

Where

U is the utility of the profile, X_s the value of attribute (level) and β_s is the (estimated) weight parameter of attribute (level). The part-worth is equal to $X_s\beta_s$. More complex constructions are possible, such as a multiplicative model for the overall utility or the presence of interaction effects in the utility function.

Perceptions about relative advantages of chickpea technologies

In order to get information and insight on household heads' decision of improved and new technologies use, perceptions' about each attribute of a given technologies is of paramount importance. Hence, farmers' knowledge for evaluation criteria about technology attributes is important. Farmers' knowledge about improved chickpea technologies (new varieties or seed, bio-inoculant and fertilizer) and their attributes are important for adoption of technologies. Technology adopter and non-adopter farmers about each technology for the increment of chickpea crop production and productivity.

The attributes of improved chickpea varieties (yield, maturity, and pod per plant, disease resistance, and marketability and seed color), bio-inoculant and chemical fertilizer are concern for this study. Four descriptions are superior, same, inferior and don't know were employed to facilitate the comparison of improved seed with local seed, with and without bio-inoculant and with and without chemical fertilizer for the production of chickpea crop. The assessment of perception of improved technologies was on both user and non-user farmers. Descripitive statistics analysis was employed.

3.5 Definition of variables and hypotheses

I. Dependent variable

Adoption status: this is the dependent variable that is used to know whether the households are adopters or non-adopters of improved chickpea technologies. It also helps to evaluate the aggregate tobit model for the two groups (adopters and non-adopters). It is a continuous variable that a proportional size of the land allocated for improved chickpea technologies in the production of chickpea crop. This helps to evaluate the factors that affecting adoption of improved chickpea technologies.

Table 4. Adoption of chickpea technologies and their indicators

Adoption status	Indicators
Non-Adopter	• Household head has used improved technology for chickpea production in the 2015/6 production season.
Adopter	• Household head has used improved technology for chickpea production in the 2015/6 production season.

The following explanatory variables were hypothesized that influence adoption and level of adopting chickpea technology in the study district.

II. Explanatory variables: Explanatory variables were identified and listed based on review of related literatures and discussion with few experts.

Demographic variables

Household head sex: is used as dummy variable. Sex difference is one of the factors expected to influence adoption of new technologies. This is because of different socio-cultural values and norms, males have freedom of mobility, participation and interaction in various groups. These help greater access to get information. Therefore, it is hypothesized that male farmers are more likely to adopt chickpea technologies (Berihun *et al.*, 2014; Hassen Beshire, 2014).

Household head educational status: is used as dummy variable and educated household head in the family is increase the ability to analyse and use information relevant to the adoption of chickpea technology package. Hence, household head's educational level is expected to influence the probablity of adopting chikpea technologies postively (Afework and Lemma, 2015).

Age of household head: is measured in numbers of years. Olders have good experience in crop production than youngers. However, when household head age increase, he or she may also decrease the flexibility to accept new technologies. Therefore, it is difficult to determine the sign of the factor on the adoption of chickpea technology (Berihun *et al.,* 2014; Akalu *et al.*, 2014).

Family size: The Number of indivduals live in the family. It is changed in to active family labour. Household who has many active family labour, the probablity of technology adoption also increase positively (Negera and Getachew, 2014).

Experience: It is the years of experience of the household head. Long years of chickpea production experience have good decision. Therefore, it is hypothesized that many years of experience are more likely to adopt chickpea technologies (Negera and Getachew, 2014).

Economic factors

Land holding: It is an indicator of household wealth and social status in the community. This indicates that households who have relatively large land size more initiated to adopt improved technologies. In addition, the reverses are true for small size of land and as a continuous variable and hypothesize to have positive relationship with adoption process (Berihun *et al.,* 2014; Hassen Beshire, 2014; Negera and Getachew, 2014; Afework and Lemma, 2015).

Livestock holding: It is measured in Total Livestock Unit (TLU). Livestock ownership is hypothesized to be positively related to adoption of technologies because it serves as proxy for wealth status (Hassen Beshire, 2014).

Asset ownership: The total amount of physical asset owned by the household head in Ethiopian birr. High asset ownership is hypothesized to be positively related to adoption of technologies because it serves as proxy for wealth status.

Farm income: The farm income refers to the total annual cash earnings of the family from the sale of crops, livestock and livestock products after family requirement. This is to be main source of capital for purchasing agricultural inputs. Thus, households with relatively higher level of farm income are more likely to purchase or exchange improved technologies. It is measured by the amount of Ethiopian birr obtain from sale of farm products (Afework and Lemma, 2015).

Number of plots: A number of plots of land that hold by the household head. Number of plots of land may increase farmer’s transaction and investment costs. Hence, it is hypothesized that a number of plots increase, technology adoption decision more likely decrease.

Social variables

Social participation: Household head particpate in membership and leadership in cooperative organization frequently more likely to be aware of new practices. Therfore, it is hypothesized that those farmers who participate in some cooperative organization as member or leader and more frequently participate is more likely to adopt chickpea technologies (Solomon *et al.*, 2011).

Social relationship: It is a number of relative and non-relative people rely on critical time in the social system. This assumed that farmers who have many people with him/her during critical time, they can access to information and confidential about improved farming practices as compared to others and hypothesised to influence adoption of chickpea technology positively (Solomon *et al.*, 2011).

Instituational variables

Distance to a nearest market center: It is distance to nearest input and out put market center places and it is continuous variable which is measured in minutes. The closer to a nearest marekt, the more likely to participate in modren farming activities that demand adoption of chickpea technologies. Hence, distance is expected to influence adoption of chikpea technologies negatively (Berihun *et al.*, 2014; Afework and Lemma, 2015).

Distance to a farmers training center: It is measured in minuts from home to the training center. This variable is meassered as continuous variable and hypothesized to have negative relationship with adoption of chickpea technologies (Hassen Beshire, 2014; Afework and Lemma, 2015).

Access to credit: it is measured in terms of whether respondants have got any form of credit for agricultural purposes. Financial constraints are difficult to attain maximum production and adopt new technologies. It is dummy variable and expected that credit increase the probablity of adopting improved chickpea technologies (Berihun *et al.*, 2014; Hassen Beshire, 2014; Afework and Lemma, 2015).

Distance to a nearest main road: It is measured distance to the main car road in minutes. A closer to the main road, the more likely particpate in modern farming practice activities that increase the demand of agricultural inputs and technologies. It is continuous variable and hypothesised to have negatively relationship with adoption of new technologies (Hassen Beshire, 2014; Afework and Lemma, 2015).

Agricultural extension and communication variables

Mass media exposure: is measured in terms of have access with different media (Radio, TV and printed paper). Farmers who have mass media exposure, their level of awarness should be high. Mass media plays a significant role for technology adoption. It is expected to have positive influence on technology adoption (Solomon *et al.*, 2011).

Attendance on extension events: it is measured in terms of opportunities of participation on the events i.e., household who participated on agricultral field days and trainings in the previous year. Participation in the field day and training is expected to positively influence farmers' adoption of improved chickpea production (Solomon *et al.,* 2011).

Access to market information: It is getting market information (outputs and inputs demand) that help farmers to the right dicision. Agriculteral technologies adoption is influenced by access of market information. Therefore, it is dummy variable and hypothesized to be accelerates the effective dissemination of agricultural information to the farmers there by enhancing farmers' decision to adopt new technologies. Therefore, it is hypothesized to affect adoption of chickpea technologies positively (Negera and Getachew, 2014).

Behavioral variables

Perception on technology: for this study, in order to evaluate the overall quality of improved (new) varieties, an index is developed. The procedure involves counting the number of superior, same, inferior and don't know traits and multiple them by their corresponding grades (i.e 3, 2, 1 and 0, respectively), adding up and dividing the sum by the number of traits. Since the overall preference index measures the general quality of technology attributes (yield, maturity, pod per plant, disease resistance, marketability and seed color), it is used in the adoption models as dummy (define as 1 if the overall preference is above the indifference or same value and 0, otherwise). This variable measures farmers' recognition of the superiority/ inferiority of improved chickpea varieties attributes that is expected to influence adoption of new technology. Hence, it is hypothesized that good perception is expected to positively influence adoption of improved chickpea technologies (Solomon *et al.,* 2011; Akalu *et al.*, 2016).

3.6 Description and measurements of variables hypotheses

Dependent variables

Table 5. Description of hypothesized variables

Dependent variables	Unit	Description
Adoption status	Dummy	
• Improved chickpea varieties • Bio-inoculant fertilizer • Chemical fertilizer /DAP		1 if a household applied each improved technology in 2015/6 cropping season for chickpea production; 0 otherwise.
Level of Adoption	Number	
1. Improved chickpea var.		1. Proportion of land covered by improved chickpea varieties during production period.
2. Bio-inoculant fertilizer		2. Proportion of land covered by bio-inoculant during production period.
3. Chemical fertilizer /DAP		3. Proportion of land covered by chemical fertilizer during production period.

Explanatory variables

Variables	Variable description and measurement	Unit	Expected sign
Sex	1 if a household head sex is male; 0 otherwise	Dummy	+/-
Education	1 if a household head is literate; 0 otherwise	Dummy	+
Age	A household head age measure in years	Year	+/-
Family size	A household's total active family labor measure in man-days equivalent ratio.	Number	+
Experience	Chickpea production experience in years.	Year	+
Land size	Amount of land owned by a household	Hectare	+
Livestock	Total Livestock own by a household measure in Total Livestock Unit (TLU).	Number	+
Asset	Amount of asset own in Ethiopian birr by a household.	Birr	+
Farm income	Amount of farm income in Ethiopian birr was got by a household.	Birr	+
Plot number	Number of plots of land own by a household.	Number	-
Cooperative	1 if household head member of cooperative; 0 otherwise.	Dummy	+
Social/relay on	Number of relative and non-relative for a household's living *kebele*.	Number	+
Market distance	Nearest distance of a household's living home to main market in minute.	Minute	-
FTC distance	Distance of a household living home to *kebele* farmer training center in minute.	Minute	-
Credit	1 if a household access to credit; 0 otherwise	Dummy	+
Radio	1 if a household own radio; 0 otherwise	Dummy	+
Road distance	Distance of living house to main road in minute.	Minute	-
Field day	1 if a household participate in field days; 0 otherwise	Dummy	+
Training	1 if a household attended in agri. training; 0 otherwise	Dummy	+
Market access	1 if a household access to market access; 0 otherwise	Dummy	+
Perception	1 if a household perceived as a technology has superior attributes quality; 0 otherwise.	Dummy	+

Definition of variables and working hypothesis of technology preference

Table 6. Technology preference and expected hypothesis of variables

No	Variable Name	Description	Measurement	Expected sign
		Dependent variable		
1	Preference	Farmers' chickpea technologies adoption preference	5 likert scale 1= least preferred 2= not preferred 3= undecided 4= preferred 5= most preferred	
		Independent variables		
1	Chickpea seed • Arerti • Shasho • Natoli • Local	Chickpea seed attribute levels preferred	Dummy 1 if available in a profile otherwise 0 not available in a profile	 + + + -
2	Chemical fertilizer • With DAP • Without DAP	DAP fertilizer preference to adopt	Dummy 1 if with DAP otherwise 0 without DAP	 + -
3	Bio-inoculant • With bio-Inoculant • Without inoculant	Bio-inoculant preference to adopt	Dummy 1if with bio-inoculant otherwise 0 without bio-inoculant	 + -
4	Payment option • 50% pre-payment • 100% payment	Payment option	Dummy 1if 50% pre-payment otherwise 0 for 100% payment	 + -
5	Age	Age	Years	+/-
6	Radio ownership	Radio ownership	Dummy 1 if yes otherwise 0	+
7	Farm income	Farm income	Birr	+
8	Credit access	Credit access	Dummy 1 if yes otherwise 0	+

Table 7. Attributes and their levels of chickpea crop production technologies

Attributes	Description of attributes	Attribute level/type
Seed variety	Types of chickpea variety preferred	• Arerti • Shasho • Natoli • Local
Chemical fertilizer	Chemical fertilizer preferred by farmer	✓ With DAP ✓ Without DAP
Bio-inoculant	Bio-inoculant fertilizer preferred	• With bio-inoculant • Without bio-inoculant
Payment option	Payment option preferred by farmer	✓ 50% pre-payment ✓ 100% payment

The total number of profiles, as shown on Table 7 that can be generated with above list of attribute and its levels was 4*2*2*2=32. This size of profiles (32) might lead to information overload on a respondent farmer that will ultimately reduce accuracy of preference evaluation. This appeared to be manageable number of the respondents and also exceeds minimum number of stimuli (The number of levels across all attribute – Number of attributes + 1 = 7) that must be evaluated by the respondent to ensure the reliability of estimated parameters. In addition, farmers cannot provide proper and meaningful evaluation when large number of product profiles presented in data collection. Therefore, fractional factorial main effect was employed for this trial research by considering orthogonally. It assumes that all interactions present in stimuli are negligible. Orthogonally makes the correlation between attributes minimum for regression analysis and makes each level to appear in equal numbers (Green and Srinivasan, 1990). Five level of likert scale (least preferred, not preferred, undecided, preferred, most preferred) was used to capture each respondent preference score in the product profile generated from orthogonal array design.

4: RESULTS AND DISCUSSIONS

This part presents the findings of the study and discusses in comparison with the result of similar studies. It is organized under different sections: the first section deals with the description of demographic characteristics, socioeconomic characteristics, land holding characteristics, institutional support services, market access and communication information and social capital and networking characteristics. The second section covers the results on the status, level of technologies adoption, preference and perception of improved chickpea technologies by smallholder farmers in the district.

4.1. Descriptive statistics

4.1.1. Demographic characteristics

This section covered about sex, educational status, age, family size and labor supply variables. As shown in Table 8, from the entire household heads interviewed, about 88.8% were male headed while about 11.2% were female headed, who are divorced or widowed at the time of survey. The proportion of male headed higher than female headed. Educational level of the household heads were about 67.4% literate which included persons that write and read while the remaining was illiterate. The average age of the sample household head was found to be 48 years with the standard deviation of 10.71. This shows that most of the household heads were within the productive age.

As shown Table 8, the average family size of the sample households was 6.59 persons which are comparable to national average family size 6.8 persons (EDHS, 2016). The average labor force (labor supply) based on estimation of man-days equivalent scale of storck *et al.* 1991 was 5.49 with the standard deviation of 1.59. This indicate that, seems no labor shortage for agricultural activities in the study area. Labor is one of important input for technology adoption and crop production.

Table 8. Descriptive statistics of household characteristics

Variables	Obs. (n)	Total		Min.	Max.
		Freq./Mean	Percent/Std.		
Sex (Male)	224	(199)	(88.84)		
Education (Literate)	224	(151)	(67.41)		
Age (Years)	224	48.17	10.71	20	80
Family size (#)	224	6.59	1.82	2	10
Labor (man-day equivalent)	224	5.49	1.59	1.75	8.85

Note: Variables in parentheses are frequency and percent
Source: Computed from survey data, 2017

4.1.2. Wealth characteristics

In this part which covered livestock holding, physical asset, farm income, off-farm income and land holding are main indicator of wealth status of the household in the study area. Ethiopia is believed to have the largest livestock population in Africa. Livestock are very important for traction power, soil fertility improvement from their manure, human nutrition gain its product and income generating from live sale and their product. Based on appendix Table 1 conversation factor and as the Table 9 shown that the average livestock holding in tropical livestock unit (TLU) was found to be 5.9. This is relatively larger in the crop-livestock mixed farming system of the country. The average cow and ox owned were 1.58 and 1.88, respectively. Oxen are very essential to plough, prepare land and threshing crops. According to the result most farmers have at least one ox but not all farmers' have two oxen. It is one the factor for technology adoption and utilization. Cows also provide milk for consumption and sale, but sample household head owned few in the crop-livestock mixed farming system of the country. In general, in the study area the sampled household has better position in their TLU. This is an indicator for technology adoption.

Table 9. Livestock holding of sampled household heads (n=224)

Variable	Mean	Std.dev	Min.	Max.
TLU	5.90	3.17	0	21.54
Cows	1.58	1.17	0	9
Oxen	1.88	0.97	0	6
Bulls	0.67	0.85	0	4
Heifers	0.96	0.99	0	4
Goats	1.30	2.96	0	20
Sheep	1.80	2.65	0	15
Donkey	0.97	0.89	0	6
Horses	0.00	0.07	0	1
Mules	0.03	0.17	0	1
Chicken	6.12	7.61	0	50
Traditional bees	0.51	1.19	0	10
Modern bees	0.07	0.39	0	4

Source: Computed from survey data, 2017

Physical assets are very important to implement agricultural activities and future investment. As revealed in Table 10, average physical asset holding of the sampled household was 45,876.37 Ethiopian birr. Income is one of the factors to purchase and adopt new technology. The average farm income that comes from different farm crops was 27,337.93 Ethiopian birr. The household heads participated in off-farm employment such engaging in daily labor, handicrafts, petty trade and others. The average monthly off-farm income of the respondent farmers was about 162.69 Ethiopian birr. These additional incomes will support individual farmer to adopt technologies. Land is one of main resource for farmers to live sustainable. The average total land holds of the sampled households were 1.69 hectare of land. However, cultivated land was 1.57 hectare land while 0.12 hectare of land was uncultivated land used for perennial plant and animal grazing purpose. This was used to produce different agricultural crops on their farm fields. Chickpea one of stable food and income generating pulse crop for farmers in the study areas. In study area, from the average total arable land 37% covered by chickpea crop. This revealed that *Gondar Zuria* District is one of chickpea growing potential area in the country. Average improved chickpea varieties coverage was 50.8% of the total chickpea land coverage. However, from the sampled household heads 17% covered by bio-inoculant fertilizer and 15% covered by chemical fertilizer (DAP) for the production of chickpea crop. This result show that the application and usage of improved technologies as package for the production of chickpea was less.

Table 10. Descriptive statistics of wealth indicator variables

Variables	Obs.	Mean	Std.dev	Min.	Max.
Asset (birr)	224	45,876.37	27,462.68	3,200	208,740.00
Farm income (birr)	224	27,337.93	15,733.67	1,829	140,720.00
Off-farm income (birr)	224	162.69	419.54	0	3400
Cultivated land (ha)	224	1.57	0.77	0.00	3.38
Uncultivated land (ha)	224	0.12	0.22	0.00	1.75
Total land holding (ha)	224	1.69	0.82	0.00	3.50
Farming experience (yrs)	224	28.86	10.30	3	54
Improved chickpea land (ha)	224	0.30	0.283	0.000	1.500
Local chickpea land (ha)	224	0.29	0.257	0.000	1.500
Total chickpea land (ha)	224	0.59	0.334	0.000	1.750
Bio-inoculant land (ha)	224	0.10	0.234	0.000	1.750
Chemical fertilizer (ha)	224	0.09	0.226	0.000	1.750

Source: Computed from survey data, 2017

4.1.3. Institutional and infrastructure support services

As revealed in Table 11, average distance of the main market place is 58.66 minutes from their residence. Market place distance is one of determinant factors to sell and buy farmers' agricultural product and inputs easily. This shows there is no market accessibility problem in the area. The average distance of farmers' training center (FTC) is taken 20 minutes from households' residence. It is important to get input availability information and capacity building from agricultural experts' in the *kebele*. Experts usually address first the nearest farmers to the center about new agricultural technologies and activities. Road is one of main infrastructure to facilitate information and hasten technology adoption easily. The average distance of the main car road was about 32 minutes from farmers' residence in the *kebele* and its standard deviation was 31 minutes. According to result in Table 11, household heads' access to credit freely was about 64%. These show that there are some farmers who did not get easily access credit service in the district.

Table 11. Description statistics of institutional support services

Variables	Obs. (n)	Total		Min.	Max.
		Freq./Mean	Percent/Std.dev		
Market distance (min)	224	58.66	33.19	2	150
FTC distance (min)	224	20.09	15.67	1	90
Main road distance (min)	224	32.38	31.18	0	120
Credit access (yes)	224	(143)	(63.84)		

Note: Variables in parentheses are frequency and percent
Source: Computed from survey data, 2017

4.1.4. Communication and market information characteristics

Ownership of radio and mobile by the household head help to acquire information related to production and marketing conditions. In this regard, as shown in the Table 12, about 34% interviewed farmers have radio and 43% have mobile while others did not have radio and mobile. These communication variables are help farmers to get information about newly introduced technologies in the country and their living localities. Field visit and field day participation on the demonstrated technologies is very crucial to adopt new technology. These help farmers to compare and contrast new and existing technologies. In this condition from the sampled household interviewed about 41% participated on chickpea and related crops field day in their localities, while the others did not participate in this event. Agricultural training is also promoting acceptance of new improved technologies. In this regard, from the total interviewed farmers about 45% have got training on pulse and related crops about production and marketing activities during survey time by different organizations. Sampled respondents were around 77% got market information while others did not get easily the information. Market information is enhancing the adoption technologies.

Table 12. Description of communication and market information variables

Variables	Observation (n)	Total	
		Frequency	Percent
Radio ownership (Yes)	224	77	34.38
Mobile ownership (Yes)	224	98	43.75
Field day participation (Yes)	224	94	41.96
Training participation (Yes)	224	102	45.54
Market information (Yes)	224	173	77.23

Source: Computed from survey data, 2017

4.1.5. Social capital and networking variables

Participation of different social groups is believed to hasten the information exchange and experience sharing among individual farmers on the use of improved agricultural technologies and recommended agronomic activates. As displayed in the Table 13, about 41% of the sampled farmers were members of administrative membership in the *kebele*. The result of cooperative membership and farmers' development group were about 81% and 55%, respectively. These household heads who participated at various groups in the community are assumed to have more access to agricultural input, information and better understand about the new improved technologies. The other social network was household rely on relatives and non-relatives during shortage of income which matters for technology adoption. The survey result revealed that a household head who had on average about 28 persons during the shortage of economic and other social related issues. Household heads that have many grant in economic and relative issue from their relatives and others believed to adopt new improved technologies early than others.

Table 13. Social capital and networking variables

Variable	Obs. (n)	Total		Min.	Max.
		Freq./Mean	Perc./Std.dev		
Administrative members (Yes)	224	94	41.96		
Cooperative membership (Yes)	224	183	81.70		
Social/Rely on critical time (#)	224	28.55	28.61	0	165

Source: Computed from survey data, 2017

As in the Table 14, described the mean values or proportion values of the variables hypothesized to influence' the decision to adopt improved chickpea varieties. The result revealed that comparison between adopter and non-adopter improved chickpea technologies. The result showed that the proportion of male household head is significantly higher among adopters (58.04%) than non-adopters (30.80%). On the other hand, there is significant difference in age between non-adopter (46.7 years) and adopters (49.1 years) in the chickpea technology adoption status. Educational status of adopters (45.09%) is significantly higher than the non-adopters (22.32%). The mean of asset is also significantly higher in technology adopters (9,745.73 birr) than the non-adopters (6,538.74 birr).

Farm income also one of the determinant for technology adoption. In farm income, improved chickpea variety adopters (31,193.81 birr) have significantly higher than non-adopters (21,150.58 birr). Livestock holding size is significantly higher in adopters (6.72 TLU) than non-adopter (4.58 TLU). The t-test in the Table 12 shows that adopters (1.82 ha) have significantly larger in farm land holding than non-adopters (1.48 ha). Adopters have also significantly longer chickpea farming experience (30.1 years) than non-adopters (26.8 years). However, adopters have significantly shorter main market distance (54.53 minutes) and farmers training center (18.47 minutes) than non-adopters in main market distance (65.29 minutes) and FTC (22.87 minutes). Improved chickpea variety users were significantly higher in credit access (41.9%) than non-adopters (21.88%). In addition, adopters have significantly higher in numbers of people rely on critical time (33%) than non-adopters (22%). Communication and market information are also affecting the technology adoption. Improved chickpea variety adopters (34.82%) were significantly higher in field day participation than non-adopters (7.14%). Training participation was also significantly higher in technology adopters (38.84%) than non-adopters (6.7%). Adopters (51.34%) have significantly higher in market information than non-adopters (25.89%). Household heads, who have better technology perception, adopt the technology early. Improved variety adopters (29.91%) were significantly higher on technology perception than non-adopters (16.96%).

Table 14. Independent variables by adoption of improved chickpea technologies

Variable	Improved chickpea varieties		
	Non-adopter (n_1=86) % or mean	Adopter (n_2=138) % or mean	χ^2 or t-test (Std. err)
Age (years)	46.7	49.1	-1.65 (0.72)
Family size (#)	6	7	-1.31*** (0.12)
Asset (birr)	6538.74	9745.73	-3.53*** (3.89)
Farm income (birr)	21150.58	31193.81	-4.88*** (1.68)
Livestock (TLU)	4.58	6.72	-5.21*** (0.21)
Land size (ha)	1.48	1.82	-3.13*** (0.05)
Experience (yrs)	26.8	30.1	-2.36** (0.69)
Market (min)	65.29	54.53	2.38** (2.22)
Main road (min)	35.24	30.59	1.09 (2.08)
FTC (min)	22.87	18.47	1.97* (1.05)
Rely on (#)	22	33	-2.68*** (1.91)
Sex (% of male)	30.80	58.04	10.43***
Education (%)	22.32	45.09	5.46**
Credit (%)	21.88	41.9	2.85*
Cooperative (%)	29.46	52.23	2.29
Field day (%)	7.14	34.82	31.28***
Training (%)	6.70	38.84	44.43***
Radio (%)	12.05	22.32	0.55
Market (%)	25.89	51.34	7.61***

***, ** and * indicate level of significance at 1, 5 and 10 percent, respectively.
Source: Computed from survey data, 2017

As in Table 15, described the mean values or proportion values of variables hypothesized to influence the decision to adopt bio-inoculant in 2015/16 cropping season by their adoption status. The result revealed that comparison between adopter and non-adopter based on independent variables. Bio-inoculant fertilizer adopters have significantly higher in asset (11,548.72 birr) ownership than non-adopters' asset (7,793.69 birr). Adopters have also significantly higher in livestock holding size (7.18 TLU) than non-adopters (5.59 TLU). They have also significantly larger land size (1.91 ha) than non-adopters' land holding size (1.64

ha). Technology adopters were significantly lesser in market distance (50.69 minutes) than non-adopters distance (60.55 minutes). The proportion of administrative membership was significantly higher in non-adopters (31.7%) than adopters (10.27%). Bio-inoculant fertilizers users on their chickpea land have significantly higher in average number people rely on in critical time (46) than non-users number of people (24). Field day and training participations, market information and technology perception were highly significant differences between technology adopters and non-adopters.

As indicated in Table 15, t-test and χ^2-test showed that influence of chemical fertilizer (DAP) use for production of chickpea crop in Gondar Zuria District. The mean or the proportion value of variable was used to compare adoption status of chickpea technology. Household head asset, farm income, household rely on critical time, field day participation, training participation, radio ownership and household heads' perception about technology were significant differences with adoption statues of the technology.

Table 15. Independent variables by adoption of bio-inoculant and chemical fertilizers

Variable	Bio-inoculant fertilizer			Chemical fertilizer (DAP)		
	Non-adopter (n_1=181) % or mean	Adopter (n_2=43) % or mean	χ^2 or t-test (Std.err)	Non-adopter (n_1=187) % or mean	Adopter (n_2=37) % or mean	χ^2 or t-test (Std.err)
Age (yrs)	48.09	48.48	-0.21 (0.72)	48.46	46.73	0.89 (0.71)
Family size	6.49	7.27	-1.63 (0.12)	6.68	6.14	1.68* (0.06)
Asset (birr)	7793.6	11548.7	-3.34*** (2.79)	8143.64	10388.68	-1.85* (2.88)
farm income	26831.8	29468.2	-0.98 (1.20)	26158.05	33301.08	-2.55** (1.25)
Livestock	5.59	7.18	-3.02*** (0.21)	5.78	6.49	-1.25 (0.01)
Land (ha)	1.64	1.91	-1.93* (0.05)	1.71	1.61	0.65 (0.05)
Experience	28.33	31.12	-1.59 (0.69)	28.70	29.70	-0.54 (0.003)
Market(min)	60.55	50.69	1.76* (2.22)	59.01	56.89	0.35 (2.2)
Road (min)	31.66	35.42	-0.71 (2.08)	32.19	33.29	-0.19 (2.1)
FTC (min)	20.31	19.14	0.44 (1.05)	19.79	21.57	-0.63 (1.1)
Rely on (#)	24.40	46.09	-4.67*** (1.91)	26.59	38.57	-2.35** (0.01)
Sex (%)	70.98	17.86	0.94	73.66	15.18	0.42
Education%	52.68	14.73	2.11	58.04	9.38	2.29
Credit (%)	52.23	11.61	0.26	52.68	11.16	0.27
Cooperative	65.63	16.07	0.15	68.30	13.39	0.0112
Field day%	25.00	16.96	47.06***	29.46	12.50	20.68***
Training (%)	28.57	16.96	39.37***	32.14	13.39	22.58***
Radio (%)	26.34	8.04	1.32	25.89	8.48	5.66 **
Market (%)	58.93	18.30	9.93 ***	62.95	14.29	2.16
Perception%	41.07	14.29	27.12***	60.27	15.63	8.59**

***, ** and * indicate level of significance at 1, 5 and 10 percent, respectively.
Source: Computed from survey data, 2017

4.2. Econometrics model

4.2.1. Status of improved technology adoption

Tobit model was employed to identify factors that determine adoption status and level of adoption of improved chickpea varieties, bio-inoculant fertilizer and chemical fertilizer (DAP) technologies by smallholder farmers in the study areas. The likelihood test statistics is applied to test dependency of adoption of improved technologies on the selected independent variables in the model. The result shows that explanatory variables are simultaneously related to adoption of improved chickpea varieties, bio-inoculant fertilizer and DAP fertilizer at 1% level of significance for production of chickpea crop. These indicate that all models have good explanatory power.

Additionally, as shown in appendix 6, problems of multicollinearity checked by using VIF (Variance Inflation Factor) was found the mean 1.89 which shows that there is no problem of multicollinearity. As shown appendix 4 and 8, Heteroskedasaticity and omitted variables were also checked by Breusch-pagan test and Ramsey RESET test, respectively that shows there were no problem in the model for improved chickpea varieties. Breusch- pagan test for heteroskedasaticity indicated a large chi-square value (117.88) for bio-inoculant fertilizer and (104.67) for chemical fertilizer, this indicated the existence of heteroskedasaticity problem in the models. To obtain corrected variance estimates, robust option was applied in the final model. Lastly, Ramsey-RESET test was applied to check model specification problem, and results show there were no omitted variables in the model.

As the result revealed that (Table, 16) adoption of improved varieties were estimated. The model was estimated 19 independent variables (11 continuous and 8 categorical variables); five variables influenced significantly the proportion of land allocated for improved varieties. Distance to farmers’ training center, farm income, livestock holding, agricultural training participation and credit access were important variable significantly influence adoption level of chickpea.

Farmers’ training center (FTC) distance was negatively and significantly influences adoption of improved chickpea varieties at 1% level for adoption. This might be due to farmers who are nearest to FTC can get enough information about improved technologies and able to observe and visit early. Therefore, farmers who are nearer to farmers' training center, they are more likely to adopt improved technology. Hence, the hypothesis is true. A minute near to farmers training center leads to an increase in probability of improved chickpea varieties adoption by 0.62%. Studies by Sezgin *et al*. (2011), Negera and Getachew (2014) and Afework and Lemma (2015) also obtained a similar result in their studies.

Farm income was positively and significantly affects the adoption of improved technology at 5% significance level. This is due to the fact that farmers are getting more income from farm crop. They take a risk and responsibility about a new technology. One additional Ethiopian birr get from farm crop leads to an increase the probability of improved chickpea varieties by 11.38%. Negera and Getachew (2014) and Debelo Duressa (2015) and also reported that farm income was significant and positive effect on the adoption of technologies.

Livestock holding size is the proxy of the wealth status of the household. It was positively and significantly influence the adoption improved varieties at 10% level of significance. This shows that a larger livestock holdings more likely to adopt a new technologies. This indicates household can generate additional income from livestock and livestock product and purchase improved chickpea varieties for production purpose. A unit increase in the TLU leads to 1.92 percent increase in the probability of adoption of improved varieties and level of adoption. Studies by Adam and Yitayal (2014), Hassen Beshir (2014), Debelo Duressa (2015) and Sisay Debebe (2016) also obtained similar result. However, Negera and Getachew (2014) and Berihun *et al*. (2014) reported that negative and significant relationship with the adoption.

Agricultural training participation has a positive and very significant influence on the adoption of improved chickpea varieties at 1% level of significance. This might be training can improve capacity building and awareness creation of chickpea producers in the study area. This shows that more training participation on the pulse crop production and marketing condition more likely to adopt new and improved chickpea varieties. The result shows that being participate on training of pulse crop in the production season leads to 28.09 percent increase the adoption of improved varieties and level of technology adoption in the study area. This is consistent with the result of Sezgin *et al*. (2011), Adam and Yitayal (2014), Hassen Beshir (2014), Debelo Duressa (2015) and Akalu *et al.* (2016).

Credit access has a positive and significant effect for adoption of improved varieties. This shows that credit is grant during critical time of production and to purchase new and improved chickpea varieties in the production season. Households who have more access to credit, they are more likely to adopt improved chickpea varieties in the study area. The result shows that being access to credit leads to 11.10% increase the adoption of improved chickpea varieties and level of proportion of improved technologies in the production chickpea crop. A study by Hassen Beshir (2014), Negera and Getachew (2014), Berihun *et al*. (2014), Okeke-Agulu and Onogwu (2014) and Afework and Lemma (2015) found a similar result.

Table 16. Tobit regression result of chickpea varieties and marginal effect

Variable	Coef.	Std. Err.	t-ratio	Marginal effect
Age (yrs)	0.001	0.006	0.22	0.0009
Household size (#)	-0.007	0.023	-0.33	-0.0056
Experience (yrs)	0.004	0.006	0.59	0.0026
Market distance (minute)	0.001	0.002	0.86	0.0010
FTC distance (minute)	-0.008	0.003	-3.19***	-0.0062
Road distance (minute)	0.001	0.002	0.47	0.0006
Asset (birr)	0.054	0.062	0.87	0.0407
Farm income (birr)	0.152	0.074	2.05**	0.1138
Livestock (TLU)	0.026	0.015	1.74*	0.0192
Land own (ha)	-0.034	0.056	-0.61	-0.0256
Rely on (#)	0.001	0.001	1.15	0.0011
Sex (%)	-0.144	0.141	-1.02	0.1083
Education (%)	0.021	0.085	0.24	0.0154
Radio (%)	-0.076	0.076	-1.00	-0.0571
Cooperative (%)	0.106	0.097	1.08	0.0793
Field day (%)	-0.006	0.111	-0.05	-0.0042
Training (%)	0.374	0.113	3.31***	0.2809
Credit access (%)	0.148	0.075	1.97*	0.1110
Perception (%)	0.072	0.072	1.01	0.0544
Constant	-2.160	0.951	-2.27**	
Log likelihood		-150.23		
LR chi2(19)		80.41***		
Left-censored observations		86		
Uncensored observations		138		
Right-censored observations		0		

*******, ****** and ***** indicate level of significance at 1, 5 and 10 percent, respectively.
Source: Computed from survey data, 2017

4.2.2. Adoption of bio-inoculant fertilizer for chickpea production

Tobit model was employed to identify factors which affect bio-inoculant fertilizer adoption status and level of adoption by chickpea crop producers in the study area. As Table 17 revealed that, out of 19 explanatory variables (11 continuous and 8 categorical variables) was included for estimation 8 independent variables were significantly affect adoption status and level of adoption of bio-inoculant fertilizer in the study area. These are age, chickpea crop production experience, market distance, farmers' training center, main road distance, livestock holding, number of people relies on in critical time and field day participation.

Age of household head has negative and significant influence on adoption of bio-inoculant fertilizer at 5% level of significance. This might be due to the fact that younger farmers has better education status and more flexible on ideas and new things that would allow them adopting bio-inoculant fertilizer than older farmers. Therefore, younger farmers are more likely to adopt bio-inoculant fertilizer than older farmers in the study areas. A year decrease in the age of the household head leads to an increase in the probability of adopting bio-inoculant fertilizer by 0.67%. Similar to this, studies by Sezgin *et al*. (2011), Berihun *et al*. (2014), Debelo Duressa (2015), Akinbode and Bamire (2015) and Akalu *et al.* (2016) found similar result. However, studies by Adam and Yitayal (2014), Hassen Beshir (2014) and Sisay Debebe (2016) found negative relationship between age of respondent and technology adoption on their studies.

Chickpea production experience has a positive and highly significant influence on the status and level of adoption of bio-inoculant fertilizer at one percent level of significant in the production of chickpea crop. This indicates that, more experienced farmers in chickpea production have better knowledge and information on the chickpea production and marketing condition. Therefore, more experienced farmers in the production chickpea crop are better to adopt bio-inoculant fertilizer in the study area. A year increase in experience on production chickpea crop leads to an increase the probability of adoption by 0.89%. A study by Okeke-Agulu and Onogwu (2014) and Akinbode and Bamire (2015) found similar result.

Main market distance has a negative and significant influence on adoption of bio-inoculant fertilize at 1% level of significant. This shows that, farmers who are more nearer to the main market, they have more information about new technologies, production and marketing conditions. These farmers have more frequent visit the market and share information and experiences with other farmers. Therefore, farmers were more nearer to the main market, more likely to adopt bio-inoculant fertilizer. A minute decrease to the main market place leads to an increase the probability of adoption by 0.28%. Earlier studies by Berihun *et al*. (2014), Hassen Beshir (2014), Negera and Getachew (2014), Afework and Lemma (2015), Akinbode and Bamire (2015) and Debelo Duressa (2015) revealed similar result on their findings.

Farmers training center distance has a negative and significant influence on adoption of bio-inoculant fertilizer at 10% level of significant. This helps farmers to get advice frequently from agricultural experts about improved agricultural inputs and activities. In addition, new technologies are tested and demonstrated on the farmers training center before distributed and applied by farmers. This is an opportunity for farmers, who are living nearer to the FTC, more likely to adopt bio-inoculant fertilizer in the stud area. A minute decrease to FTC in the living *kebele* leads to an increase the probability of adoption by 0.24%. Sezgin *et al*., (2011), Hassen Beshir (2014) and Debelo Duressa (2015) found a similar result on their studies.

Main road distance has a negative and significant effect on the adoption bio-inoculant fertilizer at 1% level of significant in the study area. This might be the fact that farmers are living nearer to the main road are more likely to get information about new technology, information marketing of input-out and experience than other farmers live far from the main car road in the study area. This encourages farmers to adopt bio-inoculant fertilizer. A minute decrease to the main car road in the living *kebele* leads to an increase the probability of adoption by 0.31%. Studies by Hassen Beshir (2014) and Debelo Duressa (2015) also found the negative relationship between distance of main road and technology adoption.

Livestock holding has a positive and significant on the adoption of bio-inoculant fertilizer at 10% level of significant in the study area, indicating that farmers with large number of livestock are more likely to adopt bio-inoculant fertilizers than others. This is because of farmers with relatively more livestock can make generate more income from livestock and livestock products to purchase bio-inoculant fertilizer. A unit increase in the TLU leads to an increase in the probability of adoption of bio-inoculant fertilizer by 1.26%. Previous studies by Adam and Yitayal (2014), Berihun *et al*. (2014), Hassen Beshir (2014), Debelo Duressa (2015) and Sisay Debebe (2016) also found a similar result. However, Negera and Getachew (2014) found negative relationship between fertilizer adoption and livestock rearing in their studies.

Relative and other people rely on critical time shows farmers social relationship and their networking in their environment. It has a positive and significant on the adoption of bio-inoculant fertilizer at 1% significant level for production chickpea crop in the study area. This indicates that more social capital and networking is helping to share information, resources and minimize risks of problems and thereby encourages the adoption of new technologies. Therefore, people have more social networks are, more likely adopting bio-inoculant fertilizer. A unit increase in number of people relies on in critical time leads to an increase the probability of adopting bio-inoculant fertilizer by 0.14%. A study by Miah *et al*., (2015) found the same result on their research finding.

Finally, field day participation has a positive and significant effect on adoption of bio-inoculant fertilizer at 1% of significance, implying that farmers who participate on field day event organized by office of agriculture and agricultural research center have better information and knowledge about bio-inoculant fertilizer technology and hence more likely to adopt the technology than non-participant farmers in the study area. Result shows that participate in the field day event leads to an increase the probability of adoption the technology by 17.83% in the study area. Akalu *et al.* (2016) and Sezgin *et al*. (2011) also found a similar research result on their studies.

Table 17. Tobit regression of bio-inoculant and chemical fertilizers and marginal effects

Variables	Bio-inoculant fertilizer				Chemical fertilizer (DAP)			
	Coef.	Robust std. err.	t-value	Marginal effect	Coef.	Robust std. err.	t-value	Marginal effect
Age	-0.029	0.013	-2.28**	-0.0067	-0.025	0.015	-1.71*	-0.0048
Family size	-0.011	0.041	-0.28	-0.0026	-0.167	0.058	-2.90***	-0.0324
Experience	0.039	0.011	3.41***	0.0089	0.024	0.011	2.17**	0.0047
Market dist.	-0.012	0.004	-2.92***	-0.0028	-0.003	0.004	-0.66	-0.0005
FTC dist.	-0.010	0.006	-1.76*	-0.0024	0.007	0.006	1.32	0.0014
Road dist.	-0.013	0.004	-3.37***	-0.0031	-0.001	0.004	-0.27	-0.0002
Asset	-0.026	0.152	-0.17	-0.0060	0.443	0.147	3.02***	0.0861
Farm income	-0.120	0.108	-1.11	-0.0276	0.099	0.148	0.67	0.0192
Livestock	0.055	0.024	2.33**	0.0126	-0.041	0.032	-1.28	-0.0079
Land size	-0.054	0.106	-0.51	-0.0124	-0.302	0.149	-2.03**	-0.0587
Rely on	0.006	0.002	2.81***	0.0014	0.004	0.003	1.73*	0.0009
Sex	0.177	0.316	0.56	0.0405	0.541	0.278	1.95*	0.1051
Education	-0.229	0.208	-1.10	-0.0525	0.619	0.224	2.76***	0.1201
Radio	-0.183	0.160	-1.14	-0.0418	0.288	0.164	1.75*	0.0559
Cooperative	-0.148	0.212	-0.70	-0.0339	-0.159	0.218	-0.73	-0.0309
Field day	0.779	0.192	4.07***	0.1783	0.352	0.233	1.51	0.0683
Training	0.369	0.199	1.85*	0.0844	0.759	0.255	2.98***	0.1473
Credit	0.016	0.148	0.11	0.0037	0.247	0.169	1.46	0.0479
Perception	-0.192	0.147	-1.30	-0.0439	0.385	0.165	2.33**	0.0748
Constant	0.741	1.950	0.38		-4.562	1.827	-2.50	
Log likelihood			-82.237		Log likelihood			-82.86
F(19, 205), Prob > F			5.46***		F(19, 205), Prob > F			5.77***
Pseudo R^2			0.3475		Pseudo R^2			0.302
Left-censored observations			182		Left-censored observations			187
Uncensored observations			42		Uncensored observations			37
Right-censored observations			0		Right-censored observations			0

*******, ****** and ***** indicate level of significance at 1, 5 and 10 percent, respectively.
Source: Compute from survey data, 2017

4.2.3. Adoption of chemical fertilizer for chickpea production

Chemical fertilizer (DAP) is very important to boost production of chickpea and other crops. As Table 17 shows that, Tobit model was employed to identify factors which affect adoption of DAP fertilizer in the production of chickpea crop in the study area. In total 19 independent variables were included in the model and among them 11 variables have significant effects on adoption of chick pea technology. These are household head age, sex, radio, household size, household asset, livestock holding, land own, education level, agricultural training participation and farmer's perception about the technology.

Age of household head has a negative and significant influence on adoption of chemical fertilizer at 10% significance level on production of chickpea crop in the study area. The result shows that younger farmers have more flexible to accept and implement chemical fertilizer than older farmers. Therefore, younger farmers are more likely to adopt chemical fertilizer (DAP) in the production of chickpea crop. A year decrease in the age of household head leads to an increase in the probability of chemical fertilizer adoption by 0.48% in the study area. Previous studies by Sezgin *et al*. (2011), Berihun *et al*. (2014), Akinbode and Bamire (2015) and Debelo Duressa (2015) found a similar research result. However, other studies by Hassen Beshir (2014) and Adam and Yitayal (2014) found that older farmers are more technology adopter than younger farmers.

Household size has a negative and significant effect on the adoption status of chemical fertilizer at 1% of significant. This indicates that farmers who have less family size are more likely to use chemical fertilizer (DAP) on the production of chickpea crop than other farmers. Possible explanation for this result is that less family size can't prepare enough compost for their farm land to replace chemical fertilizer as larger family size for chickpea crop production and large family size had low input purchasing power hence large family size means more expenditure on schooling, health, clothing and food. Decrement of one additional family member in the household will lead to an increase of adoption of chemical fertilizer by 3.24% in the study area. Earlier studies by Negera and Getachew (2014) and Hassen Beshir (2014) also found a similar research result. However, Sisay Debebe (2016), Akinbode and Bamire (2015) and Adam and Yitayal (2014) found different result in their studies.

Household head asset has a positive and significant factor for the adoption of the chemical fertilizer at 10% of significant. This might be the fact that asset indicate the proxy of wealth of the household which are the source of income and facilitate the production of chickpea crop. Therefore, the more the assets own by the household head are the more likely to adopt chemical fertilizer for the production of chickpea in the study locality. A unit increases the asset in birr by the household leads to an increase of the adoption of chemical fertilizer by 8.61%. Afework and Lemma (2015) also reported that household asset encourages technology adoption in their research studies. Household land size has a negative and significant factor for the adoption of chemical fertilizer at ten significant levels. Farmers with large amount of arable land may encounter financial problems in trying to apply fertilizer in large quantities, particularly with the skyrocketing prices of fertilizer. Therefore, household heads who own larger land sizes allocate their chemical fertilizer prior for the production cereal crop. Hence, household who own less farming area, more adopt chemical fertilizer for the production of chickpea crop. A unit decrease of land own by a household leads to an increase of the adoption chemical fertilizer by 5.87% in the study area. A study by Hassen Beshir (2014) also found a similar result in his research study.

Household heads education status is one of the most important indicators of human capital. The result shows that education has a positive and significant factor on adoption of chemical fertilizer at 1% of significant. This implies that the likelihood of chemical fertilizer adoption is increased with literate farmers' educational status. Therefore, household head being participate in formal education leads to an increase the probability of adoption by 12.01% for production chickpea crop. Similar to this, studies by Sezgin *et al*. (2011), Afework and Lemma (2015), Akinbode and Bamire (2015), Debelo Duressa (2015) and Sisay Debebe (2016) found a similar result in their research findings.

Household head agricultural training participation has a positive and significant factor on the adoption of chemical fertilizer at 5% significant levels. Training is mechanism of promoting farmers knowledge and skills about production and marketing activities which increase farmers' decision making ability. Therefore, household heads that have an opportunity of participation in training of pulse crop are more likely to adopt chemical fertilizer for the chickpea production in study area. Result show that being participate in agricultural training increases the probability of chemical fertilizer adoption by 14.73% in the study area. Sezgin *et al*. (2011), Adam and Yitayal (2014), Debelo Duressa (2015) and Akalu *et al.* (2016) also found that farmers participate in agricultural trainings facilitate adoption of improved technologies. Finally, farmers' perception condition about improved technologies matter the adoptions of the technology. Perception measured how to think of an individual about the technology based on their prior information and experience. Farmers who have got good information and experience about the chemical fertilizer their perception is also good. The result shows household heads good perception has a positive and significant factor on the adoption of chemical fertilizer for the production of chickpea crop at 5% level of significant. Therefore, farmers being good perceive on chemical fertilizer for production chickpea crop leads to an increase adoption the technology by 7.48% in the study area. A study by Akalu *et al.* (2016) also found that farmers who have good perception about soil erosion problem easily adopt improved technologies.

4.2.4. Categories of adoption of improved chickpea technologies

As result shown on Table 18, there are four levels of adoption of improved chickpea package in *Gondar Zuria* district. Adoption categories were determined by proportion of land which was allocated for production chickpea crop in production season. These are non-adopter, low adopter, medium adopter and high adopter of chickpea technologies package in the district. Non-adopters were 36.6% from total respondents and zero percent covered by improved chickpea. Household heads that have not used any improved chickpea technologies for the production of chickpea crop. Low adopters were 31.3% and 1% up to 33% of farm land covered by improved technologies for the production of chickpea crop. Medium adopter farmers also were 24.1% and the proportion was 34 up to 66% of chickpea production land. Finally, high adopters were 8% and 67 up to 100% was covered by the technologies for the production of chickpea crop farm in the production season. This show that, high adopters are very low in percentage and it needs more efforts to scaling up in wider area of land and many household heads in the study area. Studies by Cicek *et al.* (2008), Zebib Kassahun, (2014), Miah *et al*. (2015), Koirala *et al.* (2015) and Akalu *et al*. (2016) also categorized adoption level with the same as low, medium and high adopters.

Table 18. Distribution of level of adoption of improved chickpea technologies

Adoption category	Obs.(n)	Adoption index range	Freq.(n)	Percent (%)
Non-adopter	224	0.00	82	36.6
Low adopter	224	0.01 – 0.33	70	31.3
Medium adopter	224	0.34 – 0.66	54	24.1
High adopter	224	0.67 – 1.00	18	8.0
Total	224	0.00 – 1.00	224	100.0

Source: Computed from survey data, 2017

Factors affecting different level of adoption of improved chickpea technologies:

As results shown on Table 19, Ordered Probit and its marginal effect are applied on levels of technologies adoption. Marginal effects were estimated. It is an indication of relative magnitude of a unit increase in the independent variables on probability of being one of adoption category levels. If the parameter is positive then an increase in independent variable, necessarily decrease the probability of being in the lowest category (y_i=1) and increase the probability of being in the highest category (y_i=3).

The study shows that non-adoption of improved chickpea technologies package is higher when there is a decrease of farm income and livestock size (TLU). Absence of training participation and credit access increase the probability of chick pea technologies non-adoption. In addition, when increase a minute distance far from farmers training center, the probability of non-adoption of chick pea technologies also increase.

Medium and high adoption levels are also influenced by different explanatory variables. Distance to farmers' training center (FTC) is negatively related to the medium and high adoption level of chickpea technologies. The marginal effects reveals that farmers who live a minute nearer to FTC, are 0.4% and 0.1% more likely in medium and high adoption level, respectively. Farm income is positively related to the medium adoption level. Farmers who have an additional Ethiopian birr, the probability of fall on medium adoption level are increased by 7.4%. Livestock size is also positively affected to the medium and high adoption level. The marginal effect shows that farmers who have one additional TLU, the probability of medium and high adoption level also increase by 1.7% and 0.5%, respectively.

Table 19. Ordered Probit regression on levels of adoption of improved technologies

Variable	Ordered Probit		Marginal effect			
	Coef.	Std. Err.	$Pr(y_i=0)$ Non-adopter	$Pr(y_i=1)$ Low adopter	$Pr(y_i=2)$ Medium adopter	$Pr(y_i=3)$ High adopter
Age	-0.012	0.013	0.004	-0.0004	-0.003	-0.001
Family size	-0.042	0.052	0.015	-0.0015	-0.011	-0.003
Experience	0.019	0.014	-0.007	0.0007	0.005	0.001
FTC distance	-0.016***	0.006	0.006***	-0.0006	-0.004***	-0.001**
Road distance	0.003	0.003	-0.001	0.0001	0.001	0.000
Asset	0.192	0.145	-0.069	0.0068	0.048	0.014
Farm income	0.293*	0.170	-0.106*	0.0104	0.074*	0.022
Livestock	0.068*	0.035	-0.024*	0.0024	0.017*	0.005*
Land own	-0.139	0.127	0.050	-0.0049	-0.035	-0.010
Plot number	-0.040	0.056	0.015	-0.0014	-0.010	-0.003
Total rely	0.004	0.003	-0.002	0.0001	0.001	0.000
Sex	0.351	0.320	-0.133	0.0293	0.084	0.020
Education	-0.240	0.197	0.085	-0.0048	-0.061	-0.019
Radio	-0.134	0.172	0.049	-0.0058	-0.034	-0.010
Administrative	-0.141	0.169	0.051	-0.0056	-0.035	-0.010
Field day	0.273	0.248	-0.097	0.0074	0.069	0.021
Training	0.908***	0.248	-0.314**	0.0171	0.22***	0.077**
Credit	0.335**	0.171	-0.123*	0.0174	0.083**	0.023*
Market	0.177	0.203	-0.065	0.0094	0.044	0.012
Perception	0.137	0.161	-0.049	0.0046	0.035	0.010
cut1	4.826**	1.994				
cut2	5.907***	2.007				
cut3	7.109***	2.010				
Log likelihood	-233.85					
Wald chi2(20)	92.76***					
Prob > chi2	0.0000					

*******, ****** and ***** indicate level of significance at 1, 5 and 10 percent, respectively.
Source: Computed from survey data, 2017

Training on chickpea and related pulse crop is positively affected to the medium and high adoption levels of improved chickpea technologies. Household heads who received trainings on chickpea and related pulse crops, the probability of medium and high adoption levels are increased by 22% and 7.7%, respectively. Finally, rural credit access is also positively influenced to medium and high adoption levels of improved chickpea technologies in the study area. Farmers who have got access of rural credit, the probability of medium and high adoption levels are increased by 8.3% and 2.3% respectively. A study by Almaz (2008), Cicek *et al.* (2008), Koirala *et al.* (2015) and Akalu *et al*. (2016) found a similar result on their studies.

4.3. Chickpea technologies preference analysis result

Validity and reliability tests for conjoint analysis

The test of reliability (internal consistency) for the measurement of likert scale research instrument. Croanbach's alpha was employed for instrument reliability test. As shown on Table 20 shown, Croanbach's alpha value of chickpea producers was 0.75 in the district. It revealed that greater than critical value (>0.60). A scale with an alpha coefficient value of 0.60 or more is accepted as reasonably high (Fraenkel and Wallen, 2009). Accordingly, in this study the total items of the instrument had 0.75 Cronbach's Alpha value. We concluded that based on Croanbach's alpha value, this research instrument has high level of reliability.

Table 20. Instrument reliability statistics

Cronbach's Alpha	Cronbach's Alpha based on standardized items	Number of items
0.75	0.75	12

Source: Computed from survey data, 2017

Conjoint model was examined its validity by Pearson's and Kendall's tau correlation coefficient (Green and Srinivasan, 1990). It measures of correlation between observed and estimated preferences of rank ordered variables under the study. Pearson's correlation was 0.72 and internal validity of Kendall's tau coefficient value was 1.00.

Table 21. Correlation of conjoint analysis

	Value	Sig
Pearson's R	0.7232	0.000
Kendall's tau-b	1.0000	0.000

Source: Computed from survey data, 2017

The data were tested for multi-collinearity and heteroskedasticity problems. As a rule of thumb if VIF result is lower than 10, multi-collinearity is not a serious problem (Gujarati, 2004). In this study the mean VIF value of correlation among independent variables is 1.13. This shows that, there is no multi-collinearity problem in the data. Heteroskedasticity problem was also checked using Breusch-Pagan /Cook-Weisberg test. It is revealed that there was no heteroskedasticity problem in the data.

Multiple linear regression result of conjoint profiles

The result indicates that improved chickpea technologies affect adoption preference. Improved varieties (Arerti, Shasho and Natoli) are positively and significantly influence on adoption preference of chickpea at 1% level of significance. Chemical fertilizer (DAP) and bio-inoculant fertilizer were positively and significantly influence adoption preference at 1% significant level in the study area. Credit access can overcome financial problem in the production time. Access to credit has positive and significant effect on adoption preference at 1% level of significance level. Farm income and radio ownership has also positive and significance factor for adoption preference at 10% and 5% level of significant, respectively.

Table 22. Multiple linear regressions of factors affecting adoption preference

Attribute level	Coef.	Std. Err.	t-value
Arerti	0.988	0.060	16.54***
Shasho	1.065	0.060	17.82***
Natoli	0.444	0.066	6.72***
DAP fertilizer	0.191	0.046	4.14***
Bio-inoculant	0.178	0.047	3.82***
50% pre-payment	0.401	0.046	8.72***
Age	0.003	0.002	1.46
Credit	0.226	0.046	4.97***
Farm income	0.075	0.039	1.93*
Radio	0.126	0.047	2.69**
Constant	0.911	0.387	2.35**
F-statistics (df)		68.40***	
R^2 adjusted		0.201	

*******, ****** and ***** indicate level of significance at 1, 5 and 10 percent, respectively.
Source: Computed from survey data, 2017

Utility estimate of attribute level: As indicated on Table 23, chickpea varieties (Arerti and Shasho) have a positive and direct relationship to technology preference. However, Natoli and local chickpea varieties are negative relationship with utility value. This indicates that Arerti and Shasho chickpea varieties have higher utility whereas Natoli and local varieties have lower utility value in the study area. In addition, chickpea production with DAP and bio-inoculant fertilizers attributes have a direct and positive relationship with higher utility value than without DAP and bio-inoculant fertilizers. This revealed that without DAP and bio-inoculant fertilizers have lower utility value in the study area. Finally, payment attribute level 50% pre-payment has positive relationship with preference (utility) value. This revealed that 50% pre-payment attribute level has higher preference (utility) value. Perhaps, farmers encounter financial problem to implement agricultural activities in the production season. However, 100% payment attribute level has inverse relationship and lower utility (preference) value in the study area. Moreover, the summation of each attribute is zero. Dagmawit (2016) reported that farmers are preferred 50% pre-payment to 100% payment in the adoption crops. The estimated utility values provide a quantitative measure of the preference for each attribute level, with larger values corresponding to greater preference. Utility values are expressed in a common unit, allowing them to be added together to give the total utility or overall preference for any combination of attribute levels (Zardari and Cordery, 2012).

Table 23. Estimate of utility at attribute level

Attribute	Attribute levels	Chickpea producers	
		Utility estimate	Std. Error
Seed (Variety)	Arerti	0.983	0.060
	Shasho	1.061	0.060
	Natoli	-0.427	0.066
	Local	-1.617	0.060
Fertilizer	With DAP	0.199	0.046
	Without DAP	-0.199	0.046
Bio-inoculant	With bio-Inoculant	0.186	0.047
	Without bio-inoculant	-0.186	0.047
Payment	50% pre-payment	0.401	0.046
	100% payment	-0.401	0.046
Constant		1.999	0.056

Source: Computed from survey data, 2017

Relative importance of Attributes

After the analysis of the data using the conjoint procedure, a utility score, part-worth, for each attribute level is calculated. The utility scores are analogous to regression coefficients; provide a quantitative measure of the preference for each attribute level, with larger values corresponding to greater preference.

Part-worth is expressed in a common unit which allows them to sum up to give the total utility (preference) for any combination of attribute levels. The part-worth is constitutes a model for predicting the preference of any improved chickpea technologies package profile (Zardari and Cordery, 2012; Oyatoye *et. al*., 2016).

The range of the utility values (highest to lowest) for each factor provides a measure of how important the attribute was to overall preference. Attributes with greater utility ranges play a more significant role than those with smaller ranges (Zardari and Cordery, 2012; Oyatoye *et. al*., 2016). As result on Table 24 indicate that, a measure of the relative importance of each factor known as an importance score or value. The values are computed by taking the utility range for each factor separately and dividing by the sum of the utility range for all factors. The values which represent percentages sum up to 100%. As shown on Table 24 varieties (seed) highest utility range (45%) in the improved chickpea technologies. Payment options are also greater utility ranges than DAP fertilizer and Bio-inoculant fertilizer. Hence, chickpea seeds are more important than fertilizers and payment options for chickpea crop production based on household preference.

Table 24. Relative importance of attributes

Attribute	Relative importance (%)
Seed (Variety)	45
Fertilizer (DAP)	14
Bio-inoculant	13
Payment	28
Total	100

Source: Computed from survey data, 2017

As shown on Table 25, improved chickpea technologies package's preference score (utility) of the profile number 9 (Shasho seed, with DAP fertilizer, with bio-inoculant fertilizer and 50% pre-payment option) has the highest preference value and ranked the first among all profile numbers of improved chickpea technologies packages in the study area. However, improved chickpea technologies package's preference score of a profile number 6 (local variety, without DAP fertilizer, without bio-inoculant fertilizer and full payment or 100% payment option) has the least preference (utility) score in the production of chickpea crop and ranked 12^{th} among all profile numbers in the study area.

Table 25. Total utility score and rank of preference profile

Profile Number	Total Utility	Rank
Profile number 1	0.582	6
Profile number 2	1.661	3
Profile number 3	-0.228	7
Profile number 4	-1.030	9
Profile number 5	-0.443	8
Profile number 6	-1.819	12
Profile number 7	1.769	2
Profile number 8	0.846	5
Profile number 9	1.847	1
Profile number 10	1.583	4
Profile number 11	-1.216	10
Profile number 12	-1.633	11

Source: Computed from survey data, 2017

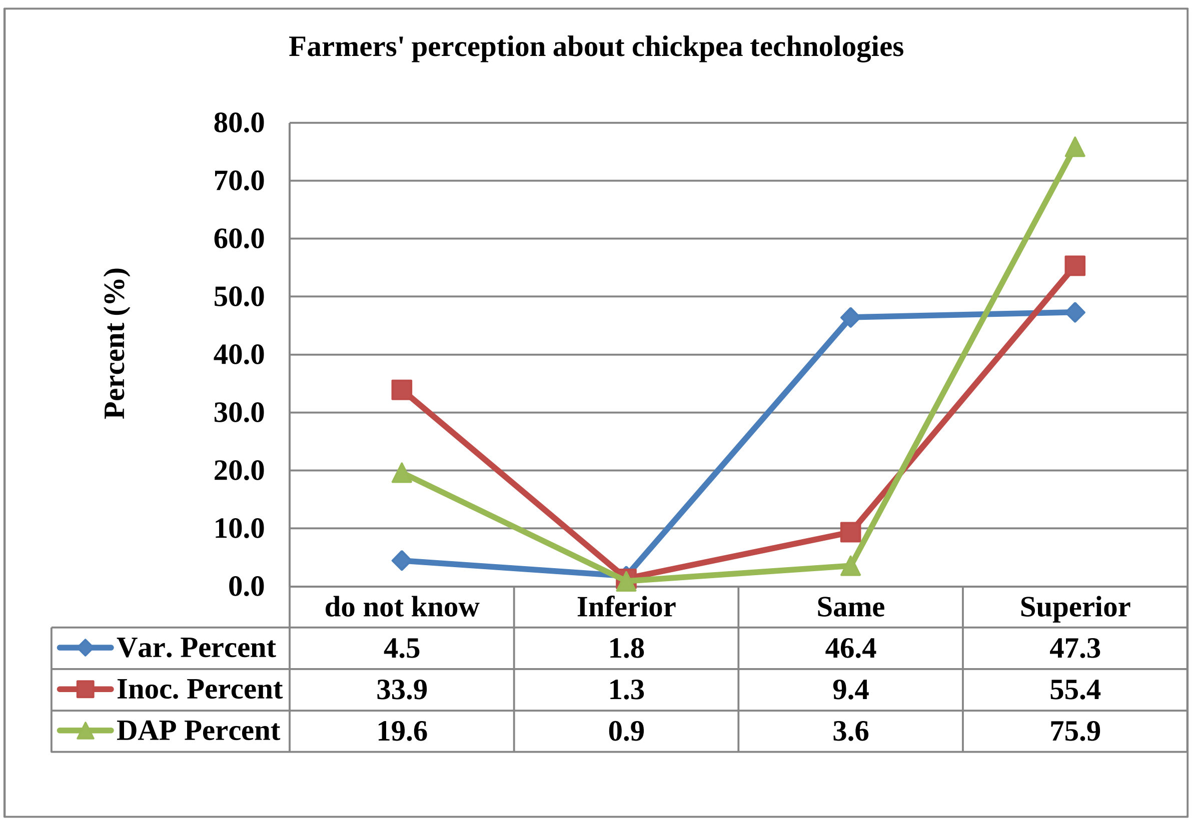
Perceptions of farmers about improved chickpea technologies

As in Figure 3 indicated that, comparison of improved chickpea technology with local technologies were analyzed. The result shows that, 4.5% of respondent farmers didn't know about improved chickpea varieties. Household heads compared the new varieties with local varieties. About 1.8% of household heads perceived that improved chickpea varieties were inferior to local varieties, and 46.4% of farmers believed that improved varieties did not have difference with other local varieties. However, 47.3% of household heads perceived that improved varieties are superior to local varieties. They perceived that improved chickpea varieties are very important for increasing production and productivity of chickpea crop.

Bio-inoculant fertilizer is very important for the production of chickpea crop. The legume-rhizobial symbiosis has a large impact on success of legume hence the atmospheric nitrogen converted into plant usable form. Hence, symbiosis can provide simple and cheap way to enhance soil fertility and increase crop production. As Figure 3 shows, about 34% of household heads did not know about bio-inoculant fertilizer that increase chickpea yield in the study area. However, about 55% of household heads perceived that using bio-inoculant fertilizer can increase chickpea yield and superior to without fertilizer chickpea production.

Chemical fertilizer (DAP) has great significance in yield increment of chickpea crop production. It is the source of phosphorous nutrient in the production of chickpea crop. As Figure 3 result shows that, about 20% of household heads have no information and knowledge about chemical fertilizer (DAP) role in increment of chickpea crop yield in the study area. About 4% of household heads perceived that chemical fertilizer is insignificant effect on chickpea yield increment. In cereal dominated farming system area, chemical fertilizer prior choose for cereal production than pulse crops. However, about 76% of household heads perceived that chemical fertilizer has a potential and superior in increment of productivity of chickpea crop in the study area. In focus group discussion household heads sorted out that chemical fertilizer preferred for *teff* and maize crop production to chickpea crop. They mentioned that it is unaffordable to buy and add chemical fertilizer on all crops production.

Figure 3. Farmers' perception about improved chickpea technologies



	do not know	Inferior	Same	Superior
Var. Percent	4.5	1.8	46.4	47.3
Inoc. Percent	33.9	1.3	9.4	55.4
DAP Percent	19.6	0.9	3.6	75.9

Source: Computed from survey data, 2017

5: CONCLUSIONS AND RECOMMENDATIONS

Ethiopian agriculture is characterized by the use of inadequate production technologies, climatic and weather fluctuations, uncertainties, and food insecurities. To solve these problems, decision makers have pursued a range of policies and investments to boos agricultural production and productivity, particularly with respect to the food stable and cash crops that are critical to reducing poverty. Hence, access, availability and usage of improved production technologies through detailed investigation on the adoption status of improved production technologies are compulsory.

The result of descriptive statistics indicates that farmers in the study area have own sufficient resources and farming experiences to undertake agricultural activities and crop production. Farmers in the study have grown different crops namely, chickpea, *teff* and sorghum as main staple crops. Many farmers produced chickpea for food and market purpose. In addition, a number of other crops and livestock production are practiced. However, performance of farmers using recommended improved agricultural technologies such as varieties, chemical fertilizer and bio-fertilizer have not been at the expected level. Hence, meaningful efforts should be made to promote use of improved agricultural technologies in chickpea production.

Distance of farmers training centers are negatively influence adoption of improved chickpea technologies in the study area. In addition, agricultural experts should address and participate farmers their residence far from the training center in the *kebele*.

Farm incomes are positively affect adoption of chickpea technologies. Farmers grow many diversified crops in the study area. These crops generate high income to farmers and assist adoption of improved chickpea technologies.

Size of livestock owned had a significant positive impact on adoption of improved chickpea technologies and high level of adoption. The study indicates that strengthening the existing livestock production system through providing better health services, better livestock feed and forage, adopting high yielding breeds and disseminating through artificial insemination in the study area.

Field day participation services significantly and positively influenced adoption of improved chickpea technologies. Field practical observation had great potential to influence farmers' decision and get information concerning about the technologies. This facilitated more adoption of the technologies in the study area. Research institutes and agricultural extensions wing should organize more field days and participate more farmers to promote and create demand on the technology in the study area.

Agricultural training participation had significant and positive influenced on the adoption status and its level of improved chickpea technologies. Training participation can improve farmers' skill, knowledge and perception about improved technologies. As a result, policies and strategies should place more emphasis on strengthening the existing agricultural extensions service provision through providing intensive training and upgrading farmers' awareness about improved technologies in the study area.

Social networking had significant and positive influence on status and level of adoption of improved chickpea technologies in the study area. Farmers who had high social network and rely on critical time more adopted improved chickpea technology package. Hence, government should appreciate and encourage communities' social capital and networking in the area. These facilitate for adoption of improved chickpea technologies in the study area.

Credit access had significant and positive impact on adoption of improved chickpea technologies in the study area. Credit access can solve financial problems to use improved agricultural inputs and facilitate agricultural investment in the study area. However, Amhara credit and saving institution (ACSI) is the only source of credit which also needs collateral borrowers and the credit amount is not enough for investment on agricultural activities. As a result, policies and strategies should give more emphasis on strengthening the existing agricultural credit service to facilitate adoption of improved technologies in the study area.

Age of household head has significant and negative impact on adoption of bio-fertilizer for production of chickpea crop in the study area. Younger farmers adopt bio-fertilizer faster than older farmers. Farmers when get older flexibility, accepting and adopting of new improved technology slower than younger farmers. Agricultural extensions should target balancing age group to share knowledge and experience when delivering training and field days participation in the study area.

Agricultural production experience has significant and positive effect on adoption of improved technologies in the study area. Experienced farmers more adopt improved chickpea technology than less experienced farmers.

The level of adoption of improved chickpea technologies package were categorized into non-adopters, low, medium and high adopters. These categories were about 36%, 31%, 24% and 8%, respectively. Non-adopters (36%) were high in the total respondent farmers. High adopters (8%) were also lower. This result indicates that, there should be need more effort to increase in to higher level of adoption in the study area.

Farmers' perception about the technologies has determined adoption of improved chickpea technologies in the study area. However, still many farmers have less perception about improved chickpea technologies. The major determinants that influenced improved chickpea technologies preference were identified. These were improved chickpea seed, DAP fertilizer, bio-inoculant fertilizer and payment option. The study has identified the most relative importance of chickpea production attribute among different factors of chickpea production. Chickpea variety (seed) is the most important and preferred factor in the improved chickpea technologies package. Payment option is also second important attribute for farmers in the study area. This is due to farmers have financial constraints to implement agricultural activities. Chemical fertilizer (DAP) and bio-inoculant are third and fourth important attributes for production of chickpea crop in the study area.

The improved chickpea technologies packages (profiles) were also identified. The package which composed of Shasho chickpea variety, with DAP fertilizer, with bio-inoculant fertilizer and 50% pre-payment is the highest preferred and ranked the first chickpea technologies package. However, a package which constitutes local chickpea seed, without DAP fertilizer, without bio-inoculant fertilizer and 100% payment is the least preferred package (profile) by farmers in the study locality.

Therefore, the following measures are recommended:-

a) It is necessary to encourage and guide farmers to use improved agricultural technologies package to boost production and productivity of crops.

b) Agricultural extension wing, research institutes, universities should give effective, targeted and crop oriented trainings about production, management and marketing activities to farmers easily adopt improved technologies.

c) New improved technologies should be demonstrated on FTC and on-farm site in wider locations; field evaluation and field days should be organized and participate many farmers at different chickpea growth stages in the study area.

d) Farmers' Training center (FTC) should be strengthened with farm materials and serve to all farmers by demonstrating recommended improved chickpea technologies in the study areas.

e) Local seed producers should be encouraged to produce quality and healthy seeds;

f) Agricultural improved inputs should be available in the required time, quality and affordable price.

g) Livestock production should be encouraged through providing better livestock feed, improved health services and breed to increase income of farmers in the study area.

h) Rural credit services should be encouraged and improve its services i.e. should give required amount, enough credit payback period and solve need of credit collateral condition.

i) Rural infrastructure should be established and strengthened to facilitate adoption of improved chickpea technologies.

j) Chickpea production and technologies application experience should be strengthened among farmers.

k) Shasho chickpea variety type with recommended package should be available for farmers in Gondar zuria district.

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APPENDIX A. Conversion factors and test statistics

Appendix Table 1. Conversion factors used to compute livestock units (TLU)

Livestock category	Conversation factors
Calf	0.25
Weaned calf	0.34
Bull	0.75
Heifer	0.75
Cow or Ox	1.00
Horse/Mule	1.10
Donkey (adult)	0.70
Donkey (young)	0.35
Camel	1.25
Sheep/Goat (adult)	0.13
Sheep/Goat (young)	0.06
Chicken	0.013

Source: Storck *et al.,* 1991

Appendix Table 2. Conversion factor used to compute man-days equivalent

Age group year	Male	Female
<10	0	0
10-13	0.2	0.2
14-16	0.5	0.4
17-50	1.0	0.8
>50	0.7	0.5

Source: Storck *et al.,* 1991

Appendix Table 3. Shapiro-Wilk test of normality of residuals

Variable	Obs.	W	V	Z	Prob>z
Residual	224	0.92	13.02	5.94	0

Appendix Table 4. Breusch-Pagan/Cook-Weisberg test for heteroskedasticity

chi2(1)	2.69
Prob > chi2	0.11

Appendix Table 5. Heteroskedasticity and omitted variable tests by IM-test

Source	Chi-2	Df	P
Heteroskedasticity	196.43	200	0.56
Skewness	49.01	19	0.00
Kurtosis	5.38	1	0.02
Total	250.82	220	0.08

Appendix Table 6. Multi-collinearity test by variance inflation factor (VIF)

Variable	VIF	1/VIF
Age	3.17	0.315468
Household size	3.06	0.326985
Experience	2.10	0.476200
Market distance	2.03	0.493102
FTC distance	1.88	0.530888
Road distance	1.76	0.566716
Asset	1.58	0.631253
Farm income	1.47	0.680541
Livestock	1.37	0.729614
Land own	1.25	0.800095
Rely on	1.12	0.894667
Mean VIF	1.89	

Appendix Table 7. Collinearity statistics for variables

Variable	Sex	Education	Radio	Cooperative	Field day	Training	Credit	Perception
Sex	**1**							
Education	0.328	**1**						
Radio	0.018	0.102	**1**					
Cooperative	0.126	0.089	0.0023	**1**				
Field day	0.158	0.147	0.166	0.075	**1**			
Training	0.182	0.177	0.149	0.062	0.767	**1**		
Credit	0.087	0.052	0.062	0.076	0.056	0.017	**1**	
Perception	0.039	0.040	0.014	0.024	0.007	0.006	0.138	**1**

Appendix Table 8. Omitted variable test by Ramsey RESET test

F(3, 201)	1.22
Prob > F	0.305

APPENDIX B. Survey interview schedule

Objectives: This Survey is part of an MSc research project to analyze adoption of improved chickpea technologies by smallholder farmers in *Gondar Zuria* district of North Western Ethiopia. Information is collected at household level. Thus, household head is the respondent of this questionnaire.

Instruction to Enumerators

- ✓ Introduce yourself and get introduced with the respondent.
- ✓ Tell to the respondent about the purpose of the study.
- ✓ Check that all questions and responses are correctly filled accordingly.

Code No.:______________________

Name of enumerator: ____________

Date: _____________

Section I. Household Identification

1. Name of the household Head _____________________
2. *Kebele* _____________ Village __________
3. Agro-ecology 1= Dega 2= Woina Dega
4. Mobile Number:_____________________

Section II. Demographic Characteristics of the household

1. Composition, education level and occupation of the household members

No	Demographic characteristics	Family member, write first name only (Start with a respondent)							
		1	2	3	4	5	6	7	8
1	Sex : Male=1, Female=0								
2	Age (Years)								
3	Relation with Head Code 1								
4	Level of Schooling Code 2								
5	Main Occupation Code 3								
6	Farming Experience (Years)								
7	Experience in chickpea crop production (Years)								
8	Farming Contribution Code 4								

Code 1: 1= Spouse 2= Son/ Daughter 3= Father/mother 4= Brother/ Sister 5= Grand Child 6= Grandparents 7= other relative 8= Non-relative

Code 2: 1= Illiterate 2= Read and write 3= Primary school (1-6 Grade) 4= Junior Secondary (7-8 Grade) 5= Secondary school (9-10 Grade) 6= Preparatory (10-12 Grade) 7= college/ University

Code 3: 1= Farming 2= House wife 3= Student 4= Dependent 5=Watch after animals 6= Off-farm activity 7= Government employee 8= other, specify___________________

Code 4: 1= Fulltime 2= during peak period 3= Not at all

Section III: Access to infrastructure and asset ownership

Sub-section 3.1 : Access to Infrastructure		
	Infrastructure	Walking distance (minute)
1.	How far is the nearest Main Market from your residence?	
2.	How far is the source of Improved Seed and Fertilizer from your residence?	
3.	How far is the source of Herbicides/Pesticides from your residence?	
4.	How far is Farmer Cooperative from your residence?	
5.	How far is Kebele office of Agriculture from your residence?	
6.	How far Farmers' training center (FTC) from your residence?	
7.	How far the nearest Health Center from your residence?	
8.	How far is the nearest School from your residence?	
9.	How far is the nearest Town from your residence?	
10.	How far is the Main car road from your residence?	

Sub-section 3.2: Household asset ownership

	Asset	How many […] do you have in the household?	What is the current market price of your […]?*(Take average price)* (Birr)
1.	Animal scotch cart		
2	Generator		
3	Horse/mule cart		
4	Mobile Phones		
5	Grain mill		
6	Ox-plough set		
8	Radio		
9	Corrugated iron sheet		

Section IV: Land holding and Chickpea production

Sub section 4.1: Land holding (*kada/timad*) during the 2007/8 EC cropping season			
	Land category	Cultivated land size (annual+ permanent crops)	Uncultivated land size (grazing and homestead)
1.	Own land used		
2.	Rented/shared in land		
3.	Rented/shared out land		

	Sub-section 4.2: Chickpea production and technologies usage		
4.	Have you ever planted any improved chickpea seed during last five years?	1= Yes 0= No	
5.	Do you remember when you planted improved chickpea varieties for first time?	1= Yes when? _______ 0= No	
6.	Have you been growing improved chickpea continuously since you first planted it?	1= Yes 0= No, If the response is " No", why? 1= 2= 3=	
7.	Where did you get the seed for first improved chickpea variety?	1= Neighbor & Relative 2= Office of agriculture 3= Research center 4 =Local market	5= NGOs 6= Cooperative 7 = University 8= Others
8.	Have you ever used Bio-inoculant during the last five years?	1= Yes when? _______ 0= No	
9.	Have you been using Bio-inoculant continuously since you first applied it?	1= Yes 0= No, If the response is " No", why? 1= 2= 3=	

10.	Where did you get the Bio-inoculant for the first?	1= Neighbor and Relative farmer(s) 2= Office of agriculture 3= Research center 4= NGOs 5 = University 6= Others
11.	Have you ever used Fertilizer (DAP) for chickpea production during last five years?	1= Yes, When?____ 0= No
12.	Have you been using Fertilizer (DAP) continuously since you first applied it?	1= Yes 0= No, If the response is ''No'', why?

Please tell us about chickpea technologies you used/purchased for the 2008/9 E.C cropping season

	Chickpea Variety Name	Quantity (kg/pack)	Is it improved? 1 = Yes 0 = No	How much did it cost (birr/kg)?	Will you recycle the seed? 1 = Yes 0 = No
1					
2					
3	Fertilizer (DAP)				
4	Bio-inoculant				

3. In 2007/8 E.C how many plots of farmland did you have? ______, let's discuss about each of the plot

		Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7
4	Name of the plot							
5	Size of plot (*kada/timad*)							
6	Ownership? Code A							
7	Who manages? Code B							
8	How far from your residence on foot? (Minutes)							
9	How fertile is it? Code C							

10	Type of soil Code D							
	Code A 1. Own 2. Rented in 3. Share cropped 4. Gift 5. Loaned for free 6. Other			Code B 1. Husband 2. Wife 3. Husband &wife 4. Children 5. Family 6. Other			Code C 1. High 2.Medium 3. Low	Code D 1.Black 2.Red 3.Brown 4.Other

In 2007/8 E.C cropping season production crop on each plot

		Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7
11	Main crops on the plot	1.	1.	1.	1.	1.	1.	1.
	(Start with Chickpea)	2.	2.	2.	2.	2.	2.	2.
		3.	3.	3.	3.	3.	3.	3.
12	Land covered by improved chickpea (*kada/timad*)							
13	Land covered by local chickpea in (*kada/timad*)							
14	Land covered by bio-inoculant for chickpea production (*kada/timad*)							
15	Land covered by fertilizer (DAP) for chickpea production (*kada/timad*)							
16	Improved chickpea varieties grown name	1.	1.	1.	1.	1.	1.	1.
		2.	2.	2.	2.	2.	2.	2.
17	Yield of Improved chickpea varieties (kg)	1.	1.	1.	1.	1.	1.	1.
		2.	2.	2.	2.	2.	2.	2.
18	Local chickpea varieties grown name	1.	1.	1.	1.	1.	1.	1.
		2.	2.	2.	2.	2.	2.	2.

19	Yield of Local chickpea varieties (kg)	1.	1.	1.	1.	1.	1.	1.
		2.	2.	2.	2.	2.	2.	2.
20	Total yield of for all chickpea varieties (kg)							
21	Total yield of other Crops on the plot (kg)	OC1:	OC1:	OC1:	OC1:	OC1:	OC1:	OC1:
		OC2:	OC2:	OC2:	OC2:	OC2:	OC2:	OC2:

NB. *OC indicates that 'other crops' which are produced in the plot.*

Let's discuss about quantity of fertilizer and chemicals used in 2007/8 EC for crop production

			Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7
	Fertilizer	Used for [..]?							
22	Urea (kg)	Chickpea							
		Other crops							
		Total							
23	DAP/NAS (kg)	Chickpea							
		Other crops							
		Total							
24	Manure (*kesha*)	Chickpea							
		Other crops							
		Total							
25	Compost (*kesha*)	Chickpea							
		Other crops							
		Total							
26	Bio-	Chickpea							

	inoculant (pack)	Other crops							
		Total							
			Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7
	Chemical	Used for [..]?							
27	Herbicide (kg/lt)	Chickpea							
		Other crops							
		Total							
28	Insecticides (kg/lt)	Chickpea							
		Other crops							
		Total							
29	Fungicide (kg/lt)	Chickpea							
		Other crops							
		Total							

Availability of Labor

30. Do you face labor shortage for chickpea production? 1= Yes 2= No

31. If you yes, for which operation/s? 1= plowing 2= planting 3= weeding 4= harvesting 5= other, specify

32. How do you overcome the labor shortage? 1= Wobera 2= Debait 3= hired labor 4= other, specify

33. If you hired labor last year for chickpea production, how many working days?__________

34. Can you easily get labor to hire whenever you need? 1= Yes, easily 2= Yes, but sometimes with difficulty 3= No

35. If No, why? 1= there is no labor market 2= I don’t have the means to hire labor 3= other, specify?

SECTION V: Livestock Ownership

Sub-section 5 : Livestock ownership, selling and buying activities over the last 12 months							
	Livestock type	How many […] currently own?	What is the current market price […]? Average price (*birr*/unit)	Selling		Buying	
				Quantity sold	Average price (birr/unit)	Quantity bought	Average price (birr/unit)
1	Cows						
2	Oxen						
3	Bulls						
4	Heifers						
5	Goats						
6	Sheep						
7	Donkeys						
8	Horses						
9	Mules						
10	Chicken						
11	Traditional bee hives						
12	Modern bee hives						

Section VI: Social Capital and Networking

Household is Member of any Formal or Informal Institution.			
	Type of group/association	Is anyone in the family a member of […]? 1=Yes, 0=No	Who is the member? 1= Husband 2=Wife 3= Children 4= Husband & wife 5=All
1.	Multi-purpose coop.		
2.	Local administration		
3.	Farmers' association		
4.	Women's association		
5.	Youth association		
6.	Religious associations		
7.	Saving & credit association		
8.	Funeral association		
9.	For how many years have you lived in this village? __________		
10.	How many people are there in this village that you can rely on for critical support in times of need?		1= relatives _______ 2 = non-relatives_____
11.	How many people are there outside this village that you can rely on for critical support in times of need?		1= relatives _______ 2 = non-relatives_____
12.	How many traders do you know who can buy your seed and grain?		

SECTION VII: Access to Agricultural Services

Subsection 7.1: Agricultural Extension				
Let's discuss the agriculture related interactions you have had over the last 12 months:				
	Source	How many field days attended that organized by […] ?	Did you discuss about pulse crops? 1 = Yes 0=No	How many farming related trainings attended [...]?
1.	Extension service			
2.	Research service			
3.	Model farmers			
4.	Farmer cooperatives			
5.	Neighbor farmers			
6.	NGOs			

Sub-section 7.2: Market information					
	Commodity	Did you get market information before you grow [...]?		Did you get market information before you sell [...]?	
		1=Yes 0= No	If Yes source? CODE D	1= Yes 0= No	If Yes source? CODE D
7	Kabuli chickpea				
8	Local chickpea				
9	Other crops				
10	Livestock				

CODE D
1= Government extension service 4= Neighbor farmers 7= Markets
2= Government Research center 5= Seed traders 8= radio/ television
3=Farmers cooperatives 6= NGOs 9= Mobile
10= Others

Subsection 7.3: Rural Credit		
11	Are there times you have critical shortage of available funds for agricultural activities?	1=Yes 0 = No
12	Did you receive any credit of any source in the last 12 months?	1 =Yes 0 = No

Let's discuss about the types, quantity, and source of the credits you acquired			
	Have you ever received [..]?	Source CODE E	Quantity (unit)
13	Cash loan		
14	Food loan		
15	Agricultural Input loan		
	CODE E: 1 = Bank 2= Local lender 3= Neighbor farmers 4 = NGO 5 = Gov. 6 = Relatives and friends 7= Saving and credit 8= edir 9 = Other		

Section VIII: Income

1. Off-farm or Non-farm activities

1.1 Do you involve in off/non- farm activities? 1. Yes 2. No

1.2 If Yes, type of off and non-farm activities and their contribution for monthly income

No.	Activities	Days per week	Average Monthly income
1	Petty trade		
2	Salary employment		
3	Handcraft		
5	Grain and livestock trade		
6	Charcoal making		
7	Casual labor		
8	Others		

2. Chickpea production, income and damage during last production year

Varieties	area (*timad/kada*)	production (kg)	amount sold (kg)	sales income (Birr)	amount consumed (kg)	amount damaged (kg)	amount stored to date (kg)
Improved							
Local							

NB. Improved Varieties are Arerti, Shasho and Natoli

3. What are the major challenges of chickpea production? (Rank 1=highest and 5= Least)

______Drought
______High rainfall
______Lack of inputs (Varieties, Inoculant, Fertilizer, Pesticides and Labor)
______Diseases and pests
______Market

4. Which are most important agro-inputs in your opinion can increase chickpea yields in your fields? (Rank 1= highest important and 6=Least important)

No.	Input name	Rank
1.	Improved seeds	
2.	Bio-fertilizer (Inoculant)	
3.	Manure	
4.	Fertilizer (DAP)	
5.	Pesticide	
6.	Herbicide	

SECTION IX: Farmers' perception and preference to chickpea technologies

9.1 Comparison of improved chickpea technologies with local and traditional practices

Technology	Attributes of technologies	Mark '√' on the selected space		
Varieties	What do you think comparing improved and local varieties by attribute [..], improved is ?	Superior	Same	Inferior
1	Yield			
2	Pod per plant			
3	Disease and pest resistance			
4	Marketability			
5	Seed Color			
6	Taste (when it is eaten green and cook)			
Bio-inoculant	What do you think comparing with and without bio-fertilizer by attribute [..], bio-fertilizer is ?			
1	Yield			
2	Soil fertility			
Fertilizer (DAP)	What do you think comparing with and without fertilizer by attribute [..], with fertilizer is?			
1	Yield			
2	Soil fertility			

9.2 Conjoint survey questions

We show you 12 cards describing different chickpea technologies package. Please rate each card based on your preference on a scale from 1 to 5; 1 being least preferred and 5 being most preferred.

Profile Number 1

Card ID	Variety	DAP	Bio-inoculant	Payment option
1	Arerti	Without	No	Full Payment

Least Preferred Not Preferred Undecided Preferred Most Preferred
1…………………………..2……………………….3…………………4……………………5

Profile Number 2

Card ID	Variety	DAP	Bio-inoculant	Payment option
2	Shasho	With	No	50% Pre-payment

Least Preferred Not Preferred Undecided Preferred Most Preferred
1…………………………..2……………………….3…………………4……………………5

Profile Number 3

Card ID	Variety	DAP	Bio-inoculant	Payment option
3	Natoli	Without	No	50% Pre-payment

Least Preferred Not Preferred Undecided Preferred Most Preferred
1…………………………..2……………………….3…………………4……………………5

Profile Number 4

Card ID	Variety	DAP	Bio-inoculant	Payment option
4	Local	Without	Yes	50% Pre-payment

Least Preferred Not Preferred Undecided Preferred Most Preferred
1…………………………..2……………………….3…………………4……………………5

Profile Number 5

Card ID	Variety	DAP	Bio-inoculant	Payment option
5	Natoli	With	Yes	Full Payment

Least Preferred Not Preferred Undecided Preferred Most Preferred
1…………………………..2……………………….3…………………4……………………5

Profile Number 6

Card ID	Variety	DAP	Bio-inoculant	Payment option
6	Local	With	No	Full Payment

Least Preferred Not Preferred Undecided Preferred Most Preferred
1…………………………..2……………………….3…………………4……………………5

Profile Number 7

Card ID	Variety	DAP	Bio-inoculant	Payment option
7	Arerti	With	Yes	50% Pre-payment

Least Preferred Not Preferred Undecided Preferred Most Preferred
1…………………………..2……………………….3…………………4……………………5

Profile Number 8

Card ID	Variety	DAP	Bio-inoculant	Payment option
8	Shasho	Without	Yes	Full Payment

Least Preferred Not Preferred Undecided Preferred Most Preferred
1…………………………..2……………………….3…………………4……………………5

Profile Number 9

Card ID	Variety	DAP	Bio-inoculant	Payment option
9	Shasho	With	Yes	50% Pre-payment

Least Preferred Not Preferred Undecided Preferred Most Preferred
1…………………………..2……………………….3…………………4……………………5

Profile Number 10

Card ID	Variety	DAP	Bio-fertilizer	Payment option
10	Arerti	With	No	50% Pre-payment

Least Preferred Not Preferred Undecided Preferred Most Preferred
1…………………………..2……………………….3…………………4……………………5

Profile Number 11

Card ID	Variety	DAP	Bio-fertilizer	Payment option
11	Local	Without	No	50% Pre-payment

Least Preferred Not Preferred Undecided Preferred Most Preferred
1…………………………..2……………………….3…………………4……………………5

Profile Number 12

Card ID	Variety	DAP	Bio-fertilizer	Payment option
12	Local	With	Yes	Full Payment

Least Preferred Not Preferred Undecided Preferred Most Preferred
1…………………………..2……………………….3…………………4……………………5

Thank you for cooperation!!!!